ASSESSING THE ROLE OF COOPERATION MECHANISMS FOR ACHIEVING THE AUSTRIAN 2020 RENEWABLE ENERGY TARGET (Project ReFlex)

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Project Webpage:
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Executive Summary

The EU directive on the promotion of the use of energy from renewable sources ("RES directive"; 2009/28/EC) includes the European target of a 20% renewable energy share (RES) in gross final energy demand. It sets binding targets for all EU member states. The national targets under the RES directive however have not been directly based on physical potentials but on existing renewable energy production and GDP. This has led to an unequal gap between national targets and (cost-efficient) potentials. The RES directive therefore allows countries the use of "cooperation mechanisms" for reaching the national 2020 targets for renewable energy in a cost efficient manner. Countries with relatively expensive RES potentials can thereby meet their targets by purchasing RES shares from countries with relatively cheap RES potentials. The cooperation mechanisms provided in the RES directive are statistical transfer, joint projects, and joint support schemes. Statistical transfer is the (virtual) transfer of RES shares from a country, which has an excess of RES shares, to a receiving country. Within joint projects between member states (or with third countries) RES shares are transferred from projects established in the selling country with financial support from the receiving country. Finally, joint support schemes allow Member States to agree on a joint policy framework to offer support for the expansion of renewable energy production.

While the European Commission as recently as in June 2012 in its communication on renewable energy policy encouraged an increased use of the cooperation mechanisms, so far there has been limited research on how to include them in a portfolio of measures to meet national 2020 RES targets. This project aims to contribute to that debate: It offers a first assessment of the use and impacts of the cooperation mechanisms for achieving the Austrian 34% RES-target by 2020. A comprehensive model-supported analysis has been conducted that assesses the impacts of increasing domestic energy efficiency and renewable energy measures and the potential for cooperation with other (EU) countries through the use of the cooperation mechanisms. In addition to direct impacts related to RES deployment and energy efficiency measures, macroeconomic and external effects were incorporated into the analysis. By combining two levels of assumed final energy demand in 2020 with different levels of assumed capacity extension of RES technologies in Austria, six key cases were defined that lead to different shares of RES in relation to the gross final energy demand.

For all scenarios, the simulation model Green-X provided a cost-efficient track of RES capacity extension per technology, the related costs and expenditures (i.e. capital, support) as well as selected benefits (e.g. fossil-fuel and CO_2 emission avoidance). The outcomes of Green-X as well as costs for energy efficiency measures served as input to the macroeconomic modelling. In addition external effects of different scenarios, such as reduced air pollution, were quantified and incorporated into the overall assessment. Impacts were considered both in the short- (up to 2020) and long-term (up to 2050). Complementary to the quantitative analysis, a qualitative assessment of the different types of RES cooperation mechanisms was conducted. This included an assessment of design options and implementation barriers as well as a comparison of the RES cooperation mechanism to the use of the flexible Kyoto mechanisms for reaching greenhouse gas emission reduction targets. Experiences with the flexible Kyoto mechanisms, to which the RES cooperation mechanisms have parallels, have shown that the high number of factors impacting the success of a mechanism makes it extremely difficult to predict the mechanisms' actual use. Anticipated supply-demand balances may provide an indicator of future market dynamics but other factors, such as institutional or administrative barriers, may significantly influence these in practice.

Based on the results, the report concludes that a domestic underachievement of Austria's 2020 RES target and, consequently, a purchase of required RES volumes via cooperation mechanisms, cannot be recommended from an economic viewpoint. To achieve the Austrian 34% RES-target by 2020 the results suggest a mix of a strong domestic energy efficiency policy package, that reduces final energy demand by 150 PJ by 2020 and a few additional incentives to increase RES deployment above targeted levels, such as increasing budgetary caps for RES electricity or enhanced stipulation of RES in the heat sector. An overachievement of Austria's RES target (up to 36%) represents the most beneficial option, among all assessed scenarios from an economic point of view if long-term domestic macroeconomic and external effects are considered. It is assumed thereby that it is realized with a moderate increase of current RES support (beyond just increasing current budgetary caps, providing additional support for rather cost-efficient RES technology options in Austria) and a strong energy efficiency policy package. Such an overachievement of the RES target may also be an appropriate strategy for Austria to hedge against unforeseeable changes in the economic framework (e.g. a higher economic and energy demand growth than projected may reduce the share of RES) or implementation risks of planned RES or energy efficiency measures. At the same time, an overachievement of the RES target would give Austria the opportunity to sell RES volumes to other EU Member States by 2020 via statistical transfer. This could also potentially be done in the years before 2020 whenever surpluses occur. In addition to generating income from statistical transfer, Austria might also allow for renewable energy investments by other countries in the framework of joint projects. This may improve the point of departure for post-2020 targets by increasing Austria's total renewable energy production well in time. However in contrast to statistical transfers, joint projects represent a long-term commitment to (virtually) export RES which should only be followed if Austria remains to be well on track to fulfill its domestic target. At the same time, given that Austria does not depend on the cooperation mechanisms in order to meet its target, joint support schemes may not have sufficient benefits which would justify their potentially high transaction costs, in particular for the short timeframe till 2020.

Apart from the focus on Austria, this project also considered the European perspective: intensified cooperation between Member States in achieving their 2020 RES targets would allow to reduce the cost burden on the EU level significantly: Annual European support expenditures for RES-electricity for example can be decreased by several billion € in 2020. For Austria such a European cost-minimization would imply an overachievement of its target. The report therefore concludes that an overachievement of Austria's RES target economically makes sense from both an Austrian and a European perspective. Moreover, such a strategy may serve as a safeguard against unpredictable changes and could lay the foundation for future RES target achievements. Thus, a strategy aiming an overachievement of Austria's RES target would contribute to an economically attractive and future-oriented pathway for Austria's RES policy while facilitating RES cooperation across the European Union.

Table of Contents

List of Figures

List of tables

Glossary:

RES	Renewable Energy Sources
RE	Renewable Energy
EEM	Energy Efficiency measures
ÖNACE	Austrian version of the NACE classification of economic activities
NREAP	National Renewable Energy Action Plans. NREAPs were submitted to the European Commission by EU Member States in 2010
RES-E	RES-Electricity
RES-T	RES-Transport
RES-H	RES- Heat

1 Introduction

In June 2009 the EU directive on the promotion of the use of energy from renewable sources (RES) subsequently named “RES directive” (2009/28/EC) came into force establishing a common European framework for the use of energy from renewable sources including the European target of a 20% renewable energy share (RES) in gross final energy demand. It sets binding targets for all EU member states. Austria has accepted a national RES target of 34%. This target can be reached through the use of RES in electricity generation, heating and cooling and transportation. The overall RES share in gross final energy consumption is calculated using the following equation:

$$RES_{SHARE} = \frac{RES_{electricity} + RES_{heating-cooling} + RES_{transportation}}{GrossFinalEnergyConsumption}$$

The RES directive allows EU countries the use of so-called “cooperation mechanisms” to reach the national targets for renewable energy in a cost efficient manner. With these mechanisms, the directive offers the possibility for EU Member States to transfer the RES production exceeding their own targets to other Member States, so that the receiving state can also reach its goal. This opportunity for cooperation is of importance because national targets under the RES directive have not been directly based on physical potentials but on existing renewable energy production and GDP. This has led to an unequal gap between national targets and (cost-efficient) potentials. Cooperation between Member States can thus help to better exploit the most cost-efficient renewables potentials.

Cooperation mechanisms include:

1. “Statistical transfer“, the (virtual) transfer of RES shares from one EU Member State to another;
2. “Joint Projects” between member states as well as with third countries: the transfer of RES shares from projects relating to the production of renewable electricity, heating and cooling established in the selling country with financial support from the receiving country; and
3. ”Joint support schemes” where Member States can agree on a joint policy framework to offer support for RES.

The framework for these mechanisms as set in the RES directive is only a corner-stone. To implement these mechanisms there is the need of concrete concepts as well as additional investigations that display the potential and the real cost-effectiveness of the mechanisms in comparison to pure national efforts to reach the given targets.

The objective of this project was to provide a model-supported analysis of the extent to which Austria should achieve its renewable energy goal through increasing domestic energy efficiency and renewable energy or through buying or selling virtual RES volumes through the RES-cooperation mechanisms[1]. The modelling exercise took into consideration not only direct costs but also macroeconomic impacts and indirect costs enabling a comprehensive

[1] joint projects with third countries have not been considered in this project.

evaluation of the political choices. In addition, the design of the cooperation mechanisms was examined, thereby contributing to on-going European research in this field.

The project included the following steps:

Scenarios for the final energy demand in 2020: first, the project derived two scenarios for the Austrian (gross) final energy demand in 2020. In the so-called "reference-scenario" it was assumed that no additional energy efficiency measures are introduced, whereas in the "efficiency-scenario" additional energy efficiency measures in the same magnitude as foreseen in the Austrian National Renewables Action Plan (NREAP[2]) are implemented.

Costs for renewable energy technologies: in the next step dynamic cost-potential-curves for Renewable Energy Technologies in Austria were derived and this data was used to update the database of the Green-X-model. The resulting data was prepared to be sufficiently detailed for the subsequent macroeconomic modelling.

Green-X modelling: both outcomes described above were included in the Green-X model. By combining two levels of assumed gross final energy demand with different levels of assumed capacity expansion of RES-technologies, six key scenarios with respect to Austria's RES target fulfilment were developed. A reference case assuming no additional policy measures served as reference for the calculations. For all six scenarios Green-X provided a cost-efficient track of RES capacity expansion per technology, its costs as well as avoided fossil based energy and avoided carbon dioxide (CO_2) emissions. Beside the different implementation intensities of energy efficiency measures and RES deployment, the six scenarios differ with respect to the resulting RES share in gross final energy demand by 2020 – for each demand path a case of (exact) RES target compliance was modelled as well as one case for over- and one for under-fulfilment.

Macroeconomic modelling and external effects: the costs for meeting the six scenarios, the CO_2 emissions saved as well as the cost structure for RES technologies and energy efficiency measures in Austria served as input for a Computed General Equilibrium (CGE) model. The CGE model provided information about impacts of the different scenarios on economic indicators, including welfare and employment. Furthermore, data of the Green-X model regarding the extent and structure of RES-capacity extension and substituted fossil based energy was used to calculate external effects (e.g. emissions of increased/decreased harmful air pollutants). The amount of each type of harmful substances was multiplied by external damage costs. Finally, the macroeconomic and external effects were part of an integrated assessment of the scenarios.

RES cooperation mechanisms: in parallel to the modelling work the RES cooperation mechanisms were assessed regarding their possible design, advantages, disadvantages, potentials, and barriers and were compared to the flexible mechanisms of the Kyoto Protocol. Conclusions on a potential use of the RES cooperation mechanisms by Austria were drawn. The qualitative results were included in the final policy recommendations.

[2] (BMWFJ, 2010b).

2 Scenarios for the Austrian energy demand in 2020

Scenarios for the Austrian energy demand in 2020 were developed that take into account existing forecasts and politically agreed measures for Austria. The degree of detail needed was determined by the requirements of the Green-X model. For the calculation of the overall future energy demand the projections of the Austrian NREAP served as basis for the **REFLEX reference scenario** and the **REFLEX efficiency scenario** (-150 PJ in 2020 compared to 2010). Sectoral projections we made as shown in Figure 1, Figure 2, Figure 3 and Figure 4 and are compared to their projected demand development of the PRIMES Baseline (2009) scenario that serves as an input for the Green-X model for modelling other EU Member States[3]. Sectoral projections are defined for the gross electricity demand, the gross heat demand - split in grid-connected and non-grid heat- and the gross energy consumption of the transport sector, which sum up to the gross final energy consumption. To include the most recent economic developments in Austria, energy data from the year 2009 (Statistik Austria, 2009) were used.

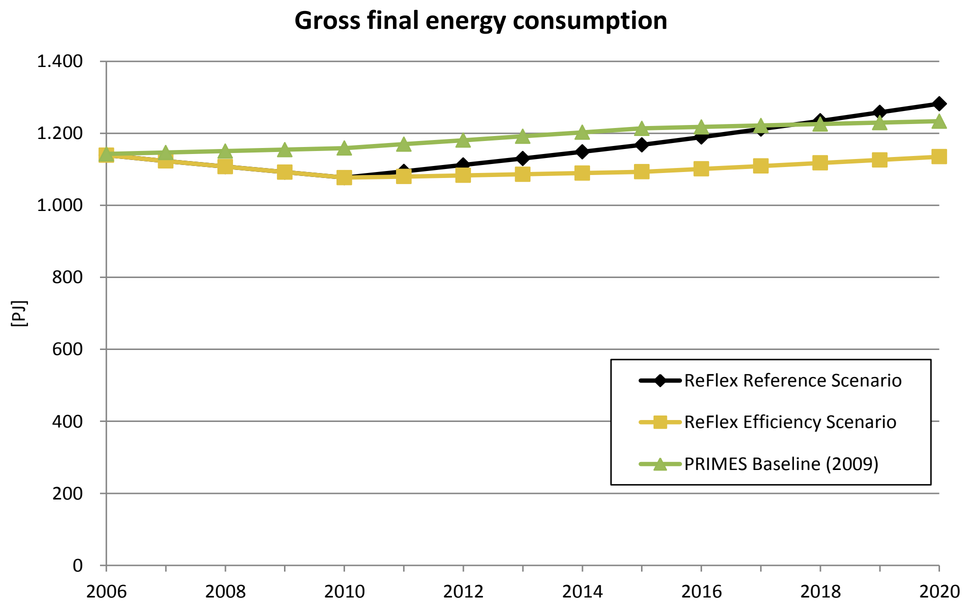

Figure 1: REFLEX Reference and Efficiency scenario of the Austrian gross final energy consumption in 2020 compared to the PRIMES Baseline (2009)

Source: NTUA, 2009; Own calculations

The gross final energy consumption in Austria projected for the year 2010 in the REFLEX scenarios is 110 PJ below the PRIMES Baseline, which is mainly an effect of the recent economic downturn. From 2010 to 2020 the REFLEX final energy demand scenario without additional energy efficiency measures (but including the effect of all those measures that have been adopted so far) - the REFLEX reference scenario surpasses the PRIMES Baseline by 43 PJ as shown in Figure 1. The implementation of an energy efficiency package in Austria is

[3] The PRIMES Baseline scenario determines the development of the EU energy system under current trends and policies; the PRIMES Baseline (2009) includes the financial crisis. Green-X uses PRIMES scenarios as input- While for Austria the REFELX reference and efficiency scenario was developed, for the other EU countries the Green-X modelling used the PRIMES Reference (2010) Scenario.

reflected in the REFLEX efficiency scenario. With a gross final energy demand of 1,135 PJ in 2020, it projects around 150 PJ less energy demand than the REFLEX reference scenario and 100 PJ less than the PRIMES baseline.

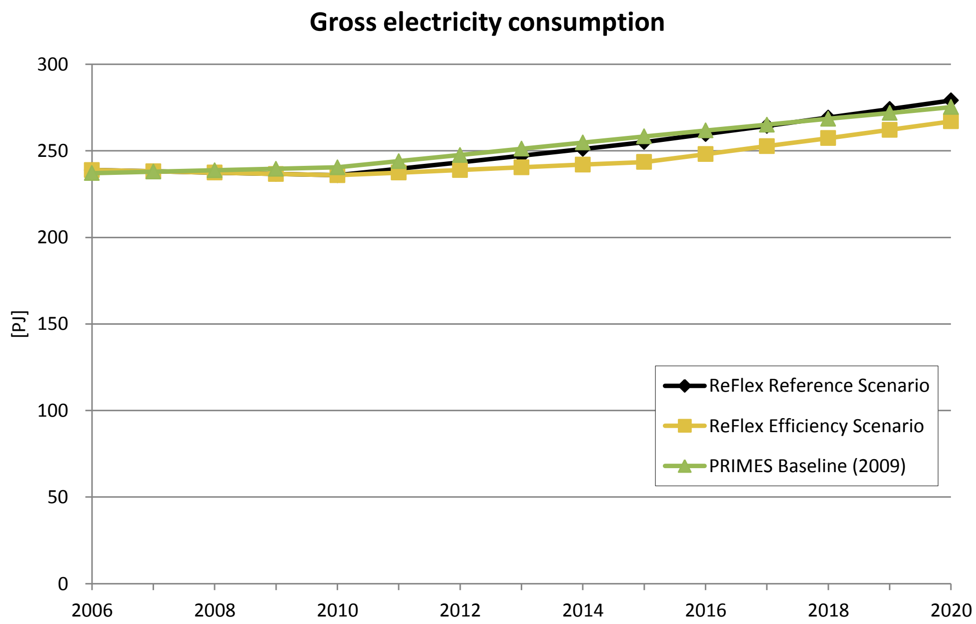

Figure 2: **ReFlex Reference and Efficiency scenario of the Austrian gross electricity consumption in 2020 compared to the PRIMES Baseline (2009)**

Source: NTUA, 2009; Own calculations

Regarding the development of the Austrian electricity consumption in a REFLEX reference case there is not much difference to the PRIMES Baseline (see Figure 2). For the year 2020 the REFLEX efficiency case is 12 PJ below the PRIMES Baseline.

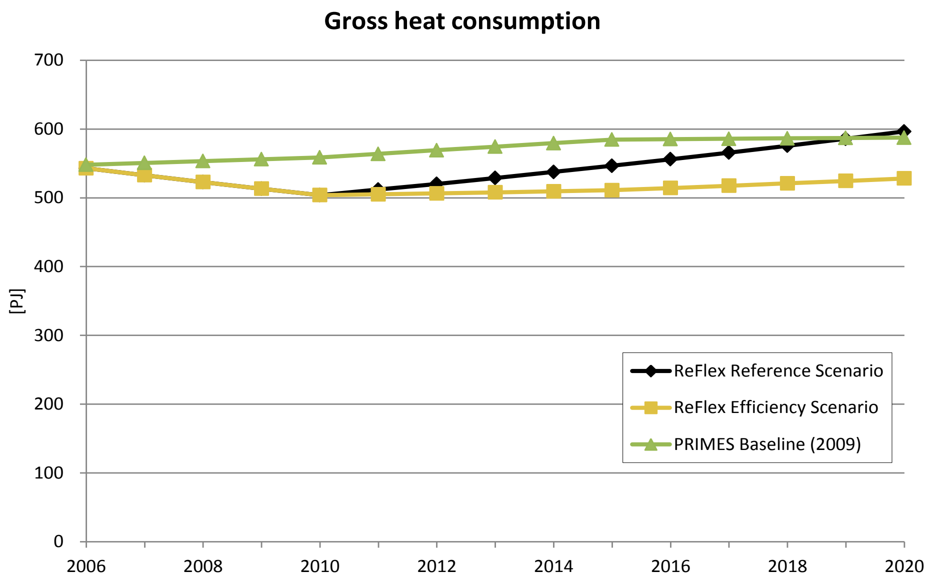

Figure 3: **REFLEX Reference and Efficiency scenario of Austrian gross heat consumption compared to PRIMES Baseline (2009)**
Source: NTUA, 2009; Own calculations

Figure 3 illustrates that the gross final energy demand scenario (reference as well as efficiency) developed in the REFLEX project related to heating purposes is substantially below the PRIMES Baseline scenario in 2010. The difference is 87 PJ. Efficiency measures should achieve energy savings of 68 PJ in the REFLEX Efficiency scenario up to 2020 compared to the REFLEX Reference scenario.

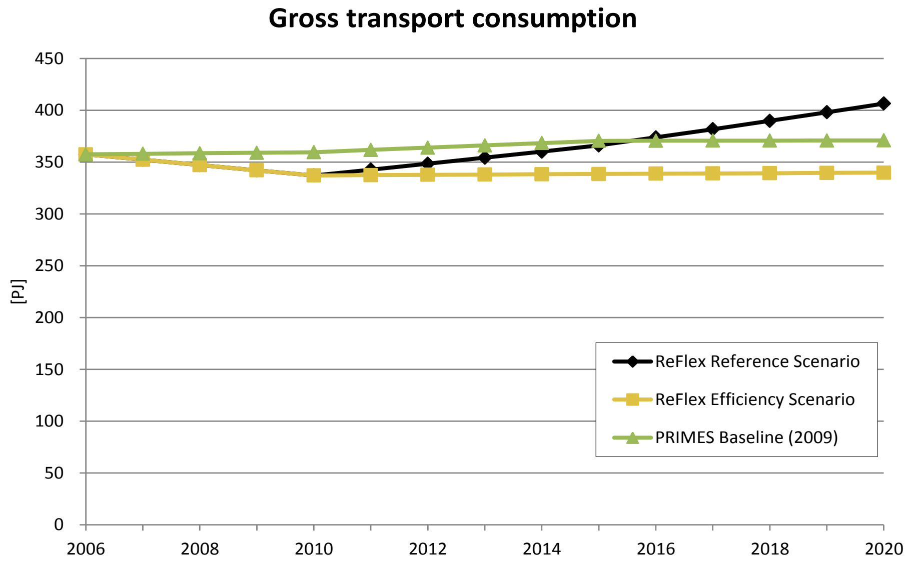

Figure 4: REFLEX Reference and Efficiency scenario of Austrian gross transport consumption compared to PRIMES Baseline (2009)
Source: NTUA, 2009; Own calculations

For the transport sector the REFLEX Reference scenario surpasses the REFFLEX Efficiency Scenario by 67 PJ in 2020 (see Figure 4).

3 Scenarios for RES expansion in the EU with a focus on Austria

This chapter describes simulated scenarios for meeting the 2020 RES targets for Austria and for other EU Member States by application of the energy simulation model Green-X[4]. Aim of this model-based assessment is to analyse options for Austria to meet the 34% RES-target for 2020 by national expansion of renewable energies, increased energy efficiency, or possible use of the cooperation mechanisms established by the RES directive. These mechanisms allow buying or selling RES shares to fulfil the target or to make profit from exceeding the targets respectively. Assessed scenarios include different assumptions on the energy policy framework for RES as well as on complementary energy efficiency measures, resulting in different levels of RES deployment in absolute terms (i.e. generated electricity, heat and biofuels) as well as in relative terms (i.e. RES share in gross final energy demand) in Austria and at the European level. The EU-wide analysis is needed specifically to assess the possibilities for cooperation on RES target fulfilment between Austria and other EU Member States.

This chapter is structured as follows: in chapter 3.1 the definition of the computed scenarios is discussed. The methodology for the assessment and a Green-X model description is presented in chapter 3.2 Methodology for the assessment- The Green-X model An analysis of the Austrian and European dimension of the scenarios and preliminary policy conclusions are discussed in chapter 3.3.

3.1 Scenario definition

Six key cases were assessed by application of the Green-X model. The results of the six cases were input for the subsequent macroeconomic modelling (chapter 4). A “Reference case” as developed in chapter 2 served as basis for the assessments. It assumed a continuation of currently implemented RES support measures. In addition, in this Reference case no complementary additional energy efficiency measures were assumed to be implemented in forthcoming years. With respect to RES technologies no removal of current non-cost barriers[5] was assumed.

The database of Green-X was adjusted according to the new insights for Austria derived in this project (see Annex 3). This includes particularly technology-specific RES potentials for Austria and the related costs as well as assumptions related to the future energy demand. The six cases of different RES technology extension differ by the overall achievable RES share in the gross final energy consumption by 2020 (i.e. variants 1, 2 and 3) and by the underlying trend with respect to the overall future energy demand growth (i.e. demand trends A with no additional energy efficiency measures and B with additional energy efficiency measures).

3.1.1 The Austrian dimension

With respect to the future development of the overall energy demand in line with chapter 2, two different energy demand paths serve as a basis for the assessments. On the one hand, a business-as-usual path assuming a continuation of past trends regarding energy demand was

[4] http://www.green-x.at/

[5] Currently the diffusion of various RES technologies is limited by several deficiencies of non-cost nature. Such deficiencies may include complex, time-consuming administrative procedures or problems associated with grid access etc.

assumed. (i.e. “path A”, applied in the reference case, case 1A, 2A and 3A). On the other hand, additional energy efficiency measures were assumed in “path B” (i.e. applied in case 1B, 2B and 3B), whereby the resulting demand development, the REFLEX efficiency case (leading to a reduction of 150PJ by 2020) is in the same magnitude as the "efficiency case" of the Austrian NREAP.

The following cases have been assessed with the Green-X model:

- Two cases (1A, 1B) where Austria achieves less than its target of 34% by 2020 31.8% in the 1A case and 32.9% in the 1B case. Consequently, for fulfilling the RES obligation of 34% (virtual) imports through the use of cooperation mechanisms is a necessity.
- Two cases (2A, 2B) where Austria exactly fulfils its RES target of 34% by 2020.
- Two cases (3A, 3B) of exceeding the RES target. With the share of 36% in both cases Austria would then possess a potential for (virtual) exports of RES shares through cooperation mechanisms.

Consequently, for achieving the above sketched RES shares in dependence of the underlying energy demand trend a different necessity for strengthening the RES support can be expected. Besides, at least for all variants aiming for a RES share of 34% or more by 2020 a mitigation of non-cost RES barriers was assumed. See Table 1 for the complete overview of the assessed cases and further explanations of the applied policy instruments.

The bandwidth of RES shares by 2020 in the different cases (i.e. ranging from about 32 to 36%) may be considered as narrow since a few proponents of the Austrian RES sector have called for stronger RES exploitation by 2020 and beyond. Policy realism and experiences from the achievement of Austrian climate targets on the other hand may ask for a lower RES share by then. Thus, the pathways assessed within this study represent a pragmatic compromise between both extremes, indicating expected (BAU cases) and required RES deployment for 2020 as well as more ambitious cases of doing more than required or targeted, considering the anticipated indicative RES target of 34.2% by 2020 laid down in the Austrian National Renewable Energy Action Plan (BMWFJ, 2010b).

Table 1: Overview of the assessed cases

Overview of assessed cases	Additional energy efficiency measures	Strengthening of current RES support[2]	Mitigation of non-cost barriers for RE[3]	RES share by 2020	Deployment of new RES (2011 to 2020) [TWh]
Reference case	No	No	No	30.2%	36,7
Case 1A - RE import	No	No[4]	Yes	31.8%	42,1
Case 2A - target compliance	No	Yes (moderate)	Yes	34.0%	50,2
Case 3A - RE export	No	Yes (strong)	Yes	36.0%	57,2
Case 1B - RE import	Yes[1]	No	No	32.9%	33,2
Case 2B - target compliance	Yes[1]	No (fine-tuning)[5]	Yes	34.0%	36,8
Case 3B - RE export	Yes[1]	Yes (moderate)	Yes	36.0%	42,9

Notes:

1 The future energy demand development in the efficiency cases is assumed to be consistent with the "efficiency case" of the Austrian NREAP.

2 As default a continuation of current RES support is a precondition. A strengthening of RES support shall consequently mean an adaptation of current practice (year 2010), which generally coincidences with a fine-tuning of technology-specific incentives and the implementation of additional support measures. Incentives for a moderate strengthening of RES support include additional support for rather cost efficient RES technology options, whereas in case of a stronger RES support strengthening the whole RES technology portfolio (to some extent also marginal RES technology options such as PV) would receive additional incentives for investments.

3 As default the diffusion of various RES technologies is limited by several deficiencies of non-cost nature. Such deficiencies may include complex, time-consuming administrative procedures or problems associated with grid access.

4 The case to achieve a RES share in gross final energy demand of about 32% by 2020 under the assumptions that no additional energy efficiency measures are taken but that current non-cost RES barriers are mitigated requires no increase of the height of current RES support levels (e.g. in terms of Euro per MWh for RES electricity). However, achieving the conditioned RES target calls for an enlargement of the budgetary caps that limit yearly RES deployment in the electricity sector.

5 The specific case to achieve a RES share in gross final energy demand of 34% by 2020 in case 2B assumes, on the one hand, that additional energy efficiency measures limit overall demand growth and, on the other hand, that current non-cost RES barriers are mitigated. It requires a fine-tuning of current technology-specific RES support measures. This means no increase of currently offered support levels but a partial removal of budgetary constraints for RES in the electricity sector. Thus, if only support levels are kept constant while all budgetary caps are removed it can be expected that an over fulfilment of the 34% RES target by 2020 will occur.

3.1.2 The EU dimension

The RES development in other EU Member States follows two storylines: the national perspective of accomplishing the EU goals with less cooperation, and the European perspective of intensified cooperation, which are as well combined with two different scenarios of final energy demand for all EU Member States. See Figure 5 for an overview of the EU scenarios and Table 2 for the exact definition of the assessed cases for the EU in line with the Austrian scenario definition. The table shows the parameter definition for the EU 27 Member States for the corresponding Austrian scenario, with the exception that the reference case with mitigation of non-cost barriers (second case in Table 2) is not a case explicitly modelled for Austria. This case will only be discussed in the European dimension results.

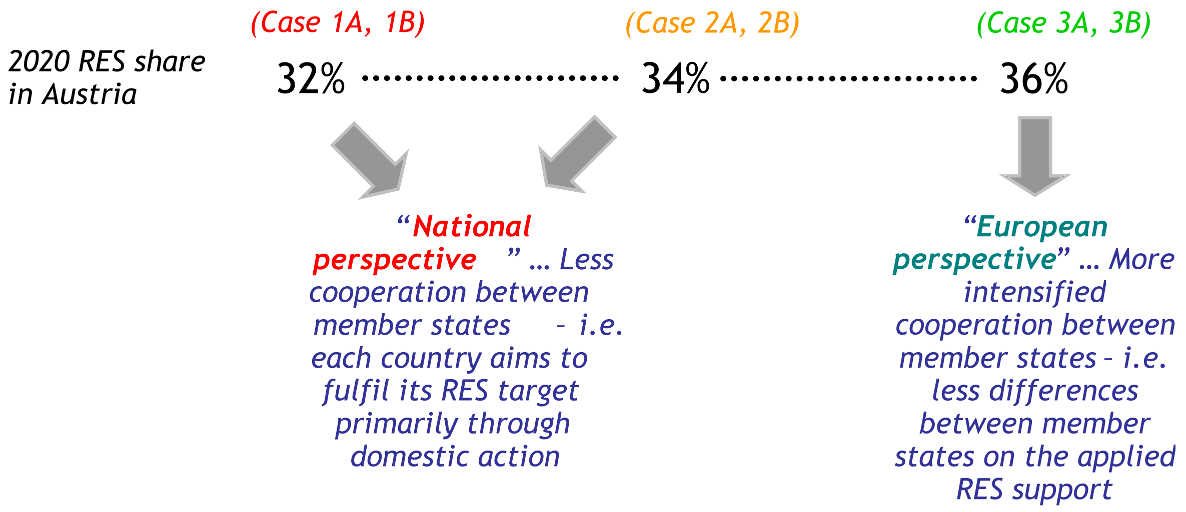

Figure 5: Description of the European dimension of the computed scenarios

Table 2: Overview of the defined parameters for the European dimension

Overview of assessed cases	Additional energy efficiency measures	Strengthening of RES support	Mitigation of non-cost barriers for RES	National or European perspective	RES share by 2020
Reference case	No	No	No	-	14,1%
Reference case with mitigation of non-cost barriers	No	No / Partly[1]	Yes	-	15,7%
Case 1A, 2A	No	Yes	Yes	national	19,8%
Case 3A	No	Yes	Yes	European	19,8%
Case 1B, 2B	Yes	Yes	Yes	national	19,8%
Case 3B	Yes	Yes	Yes	European	19,8%

Notes:
For countries like Austria which currently apply yearly budgetary caps to limit deployment of (certain) RES-E technologies the assumption is taken that the height of current financial support remains constant while caps are removed.

3.2 Methodology for the assessment- The Green-X model

Based on the previous defined scenarios a comprehensive calculation was conducted by application of the simulation model Green-X. The calculation included a variation of the energy-political framework for RES and a variation of the development of other key input parameters (e.g. energy demand). A short characterisation of the model is given in the following paragraphs, while for a detailed description we refer to www.green-x.at.
The Green-X model covers geographically the EU-27 Member States. It allows to investigate the future deployment of RES as well as accompanying costs, comprising capital expenditures, additional generation costs (of RES compared to conventional options), consumer expenditures due to supporting policies, etc. – and benefits – i.e. contribution to supply security (avoidance of fossil fuels) and corresponding carbon emission avoidance. Thereby, results are derived at country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2030. Within the model, the most important RES-Electricity (i.e. biogas, biomass, bio waste, wind on- & offshore, hydropower large- & small-scale, solar thermal electricity, photovoltaics, tidal stream & wave power, geothermal electricity), RES-Heat technologies (i.e. biomass – subdivided into log wood, wood chips, pellets, grid-connected heat, geothermal (grid-connected) heat, heat pumps and solar thermal heat) and RES-Transport options (e.g. first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulosic bioethanol, BtL) as well as the impact of biofuel imports are described for each investigated country by means of dynamic cost-resource curves. This allows, besides the formal description of potentials and costs a detailed representation of dynamic aspects such as technological learning and technology diffusion.

Besides the detailed RES technology representation the core strength of the model is the in-depth inclusion of energy policies. Green-X is fully suitable to investigate the impact of applying (combinations of) different energy policy instruments (e.g. quota obligations based on tradable green certificates/guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at country- or at European level in a dynamic framework.

Criteria for the assessment of RES support schemes

Support instruments have to be effective in order to increase the penetration of RES and efficient with respect to minimising the resulting public costs – i.e. the transfer costs for consumer (society), subsequently named consumer expenditures – over time. The criteria used for evaluating the various policy instruments are based on two conditions:

- Minimise generation costs
- Reduce producer profits to an adequate level

Once such cost-efficient systems have been identified, the next step is to evaluate various implementation options with the aim of minimising the transfer costs for consumers/society[6]. This means that feed-in tariffs, investment incentives or RES trading systems should be designed in a way that public transfer payments are also minimised. This implies lowering generation costs as well as producer surplus (PS)[7].

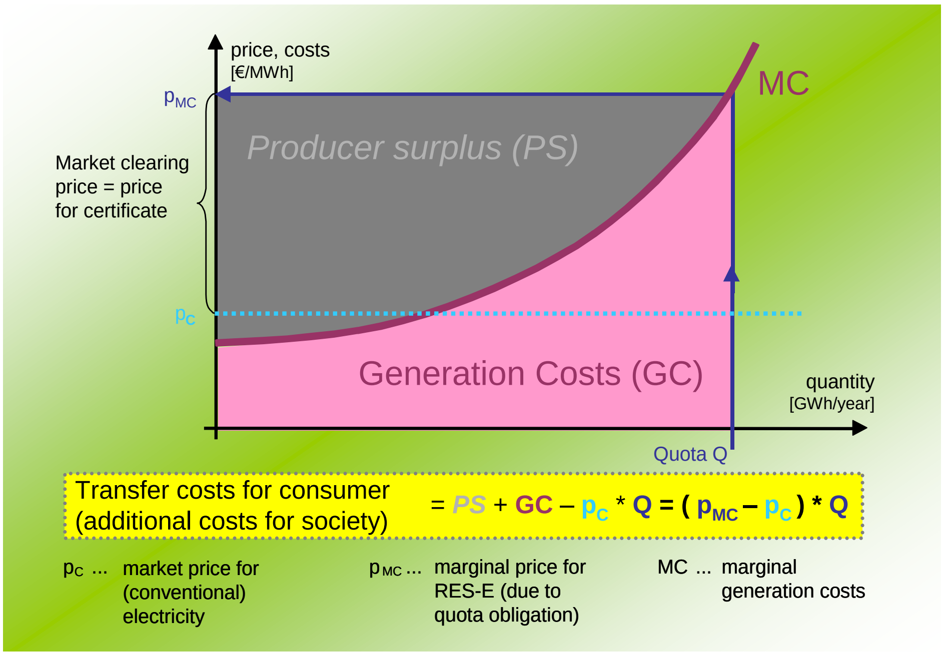

Figure 6: Basic definitions of the cost elements (illustrated for a RES trading system)

In some cases it may not be possible to reach both objectives simultaneously – minimize generation costs and producer surplus – so that compromises have to be made. For a better illustration of the cost definitions used, the various cost elements are illustrated in Figure 6.

[6] Consumer expenditures - i.e. the transfer costs for consumers (society) – due to RES support are defined as the financial transfer payments from the consumer to the RES producer compared to the reference case of consumers purchasing conventional electricity on the power market. This means that these costs do not consider any indirect costs or externalities (environmental benefits, change of employment, etc.). Within this report consumer expenditures (due to RES support) are either expressed in absolute terms (e.g. billion €), related to the stimulated RES generation, or put in relation to the total electricity/energy consumption. In the latter case, the premium costs refer to each MWh of electricity/energy consumed.

[7] The producer surplus is defined as the profit of RES-based energy production. If, for example, a RES producer receives a feed-in tariff of 60 € for each MWh of electricity sold and generation costs are 40 €/MWh, the resulting profit would be 20 € for each MWh. The sum of the profits of all RES producers equals the producer surplus.

3.3 Green-X scenario results

Subsequently we present the results of the model-based assessment of future RES deployment in Austria and in other EU Member States. Thereby, a first analysis is made related to following questions:

- How high is the potential RES deployment until 2020 in Austria and its corresponding support expenditures?
- How significant are possible benefits such as GHG reduction and supply security linked to RES deployment?
- What policy action is required for achieving the RES targets conditioned within this assessment from an Austrian and European perspective?

3.3.1 RES deployment by 2020 – the Austrian dimension[8]

The modelled scenarios for Austria vary in their RES deployment in different sectors of gross final energy demand, as can be seen in Figure 7. Thereby, biofuels in the transport sector generally achieve a comparatively constant deployment, ranging from 9.4% to 9.6% in all cases. This is in line with the mandatory 10% RES share by 2020 in the transport sector as required by the EU RES-Directive since also electricity from RES used in the transport sector (besides biofuels) has to be taken into consideration for target calculation. Thus, the sectors electricity and heat are responsible for the differences in the total RES shares between the cases. The reference case projects a 65.8% RES share for the electricity sector and a 28.5% RES share for the heat sector in 2020. In the different A-cases, which follow the reference energy demand projections to 2020, the RES share in the electricity sector (RES-E share) varies between 69.2% and 79.2% by 2020. The B-cases, which include additional energy efficiency measures, project a RES-E share from 66.6% to 72.6% by 2020. The RES share in the heat sector (RES-H share) of the A-cases ranges from 30.2% to 34.7%. With additional energy efficiency measures in place (B-cases) the RES-H share varies between 31.7% and 35.3%.

As seen in Figure 7 it becomes apparent, on the one hand, that RES-H achieves a higher share if energy efficiency plays a key role, and, on the other hand, that RES-E needs to be increased less to achieve the overall targeted RES deployment. Moreover, the comparatively strong difference in the RES-E share between case 3A and case 3B is caused by the strong strengthening of the national RES support in 3A needed to reach a 36% RES target if overall energy demand grows strong versus the moderate strengthening necessary in 3B where a package of energy efficiency measures is implemented.

[8] See Annex 1 for detailed tables with numbers for all figures of this chapter

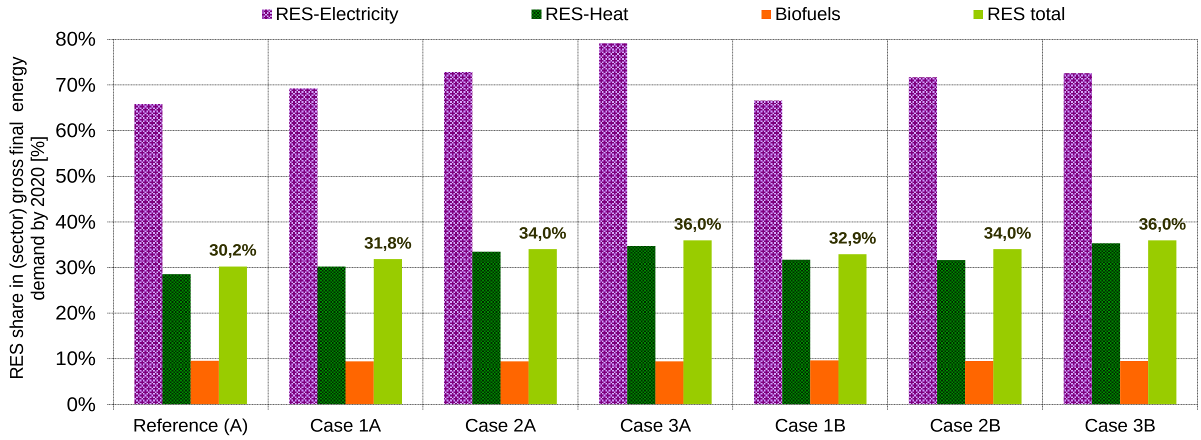

Figure 7: Comparison of the resulting RES share in (sector) gross final energy demand by 2020 in Austria for all assessed cases

The deployment of new RES systems installed in the period 2011 to 2020 is shown in Figure 8 for all six cases. It can be observed that additional energy efficiency measures anticipated in the B-cases have a considerable impact. If additional energy efficiency measures are implemented as conditioned in the B cases, a RES growth as anticipated in the reference case appears sufficient to fulfil the Austrian 34% RES goal (as modelled in the 2B scenario). This scenario implies a mitigation of non-cost barriers and only a partly strengthening of financial RES support.[9] If in addition the national support for RES technologies is strengthened moderately a 36% RES share (case 3B) can be achieved.

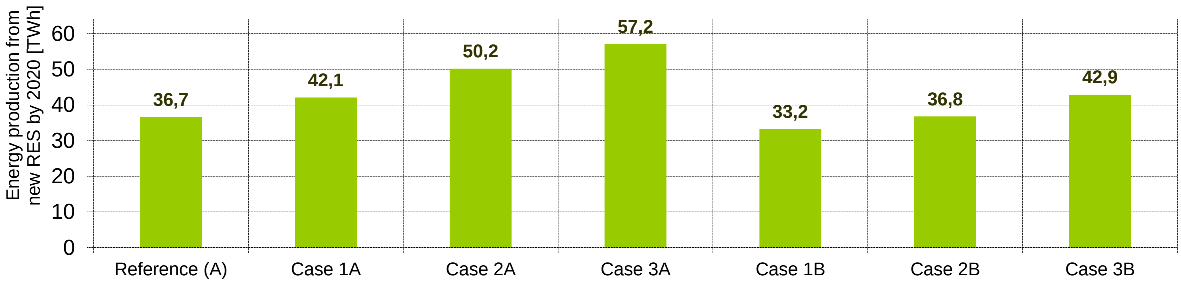

Figure 8: Comparison of the resulting total deployment of new (2011 to 2020) RES installations in Austria for all assessed cases

The resulting RES deployment in the year 2020 is a result of new installations mainly in the RES-E and RES-H sectors, as can be seen in detail in Figure 9. These sectors bear the biggest potentials for substituting conventional energy sources by RES in Austria.

[9] As discussed previously this means that no increase of currently offered support levels is required. However, a partly removal of budgetary constraints for certain RES technologies in the electricity sector represents a necessity.

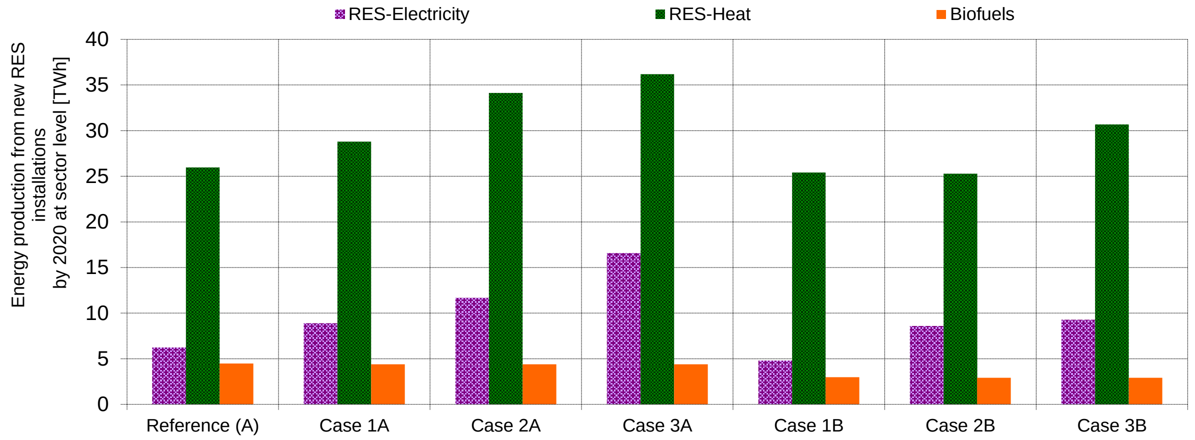

Figure 9: **per sector comparison of the resulting deployment of new (2011 to 2020) RES installations in Austria for all assessed cases**

The technology breakdown of the new RES installations in Figure 10 visualises the potential for new RES installations in Austria in more detail. Solid biomass, specifically in the heat sector, is the key contributor among all RES options in the year 2020 in all of the modelled scenarios. In the electricity sector biomass is again of key relevance followed by large and small-scale hydropower, wind onshore, and biogas and bio-waste. Electricity generation from photovoltaics is an important technology in scenario 3A and can be classified as marginal option. Heat pumps, heat from bio-waste and biogas as well as solar thermal heat are the other RES technologies beside solid biomass to realize the targeted RES volumes for 2020 in the heat sector.

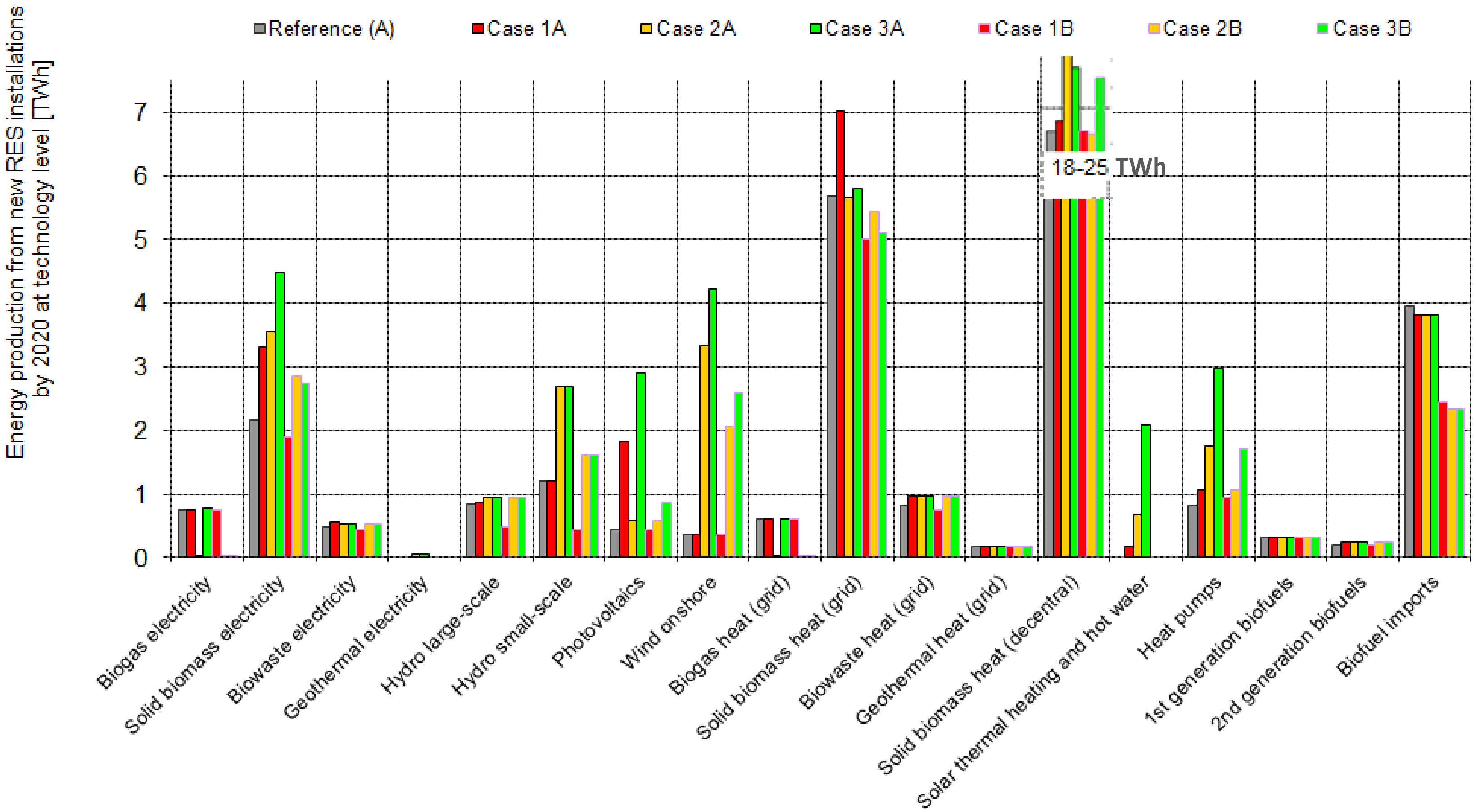

Figure 10: Comparison of the resulting technology breakdown for new (2011 to 2020) RES installations in Austria for all assessed cases
The numerical values can be found in Annex 1, Table 14.

3.3.2 Indicators on costs and benefits for Austria

Cumulative capital expenditures

A comparison of the required cumulative capital expenditures for new RES installations in the period of 2011 to 2020 is shown in Figure 11. The impact of additional energy efficiency measures is apparent:[10] To meet the 34% target with scenario 2B requires far less expenditures than with 2A. For case 3A the need for a substantially higher deployment of (currently) more costly technology options as photovoltaics or solar thermal heat collectors lead to the highest expenditures. In case 3A capital expenditures are 50% higher than in case 3B in order to achieve a similar (36%) RES share by 2020.

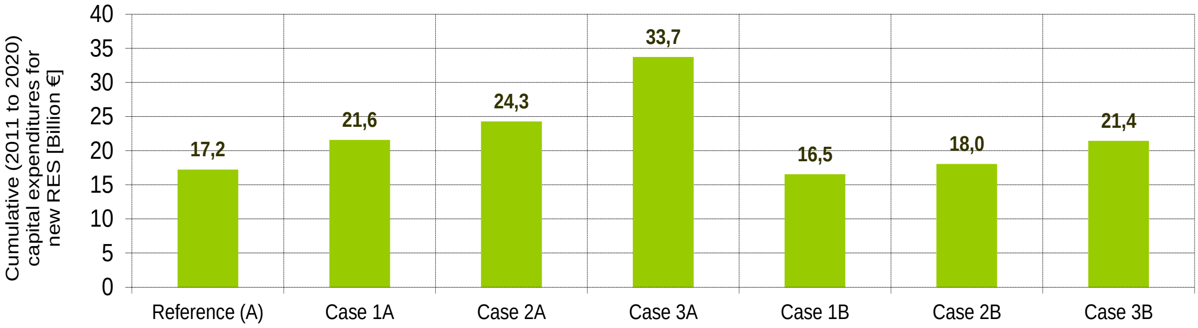

Figure 11: Comparison of the total required capital expenditures for new (2011 to 2020) RES installations in Austria for all assessed cases

Heat from biomass can be classified as cost-efficient option and as key contributor in all assessed cases. Capital expenditures for small-scale biomass heat installations range from 7 to 9 billion € among all assessed cases. This represents the majority of investments in the RES-H sector and about half of all required capital expenditures in the reference case (see Figure 11). On the other hand, certain RES-E technologies can be classified from a cost perspective as marginal options where upfront investments are comparatively high.[11]

As can be seen in Figure 12 the cumulative capital expenditures for new RES-E installations are lower in the reference case as well as in case 1A and 1B compared to RES-H. If higher targets are to be achieved, more expensive RES-E technologies have to be deployed leading to a significant increase of capital expenditures.

[10] Note that a business-as-usual path (i.e. the reference path) for demand growth is conditioned in all A cases, while all B variants reflect a stabilisation of energy demand, implying additional energy efficiency measures to be taken.

[11] Note that in contrast to high capital cost these RES-E technologies have typically low operational expenses, and, furthermore, no fuel expenses are associated with their use.

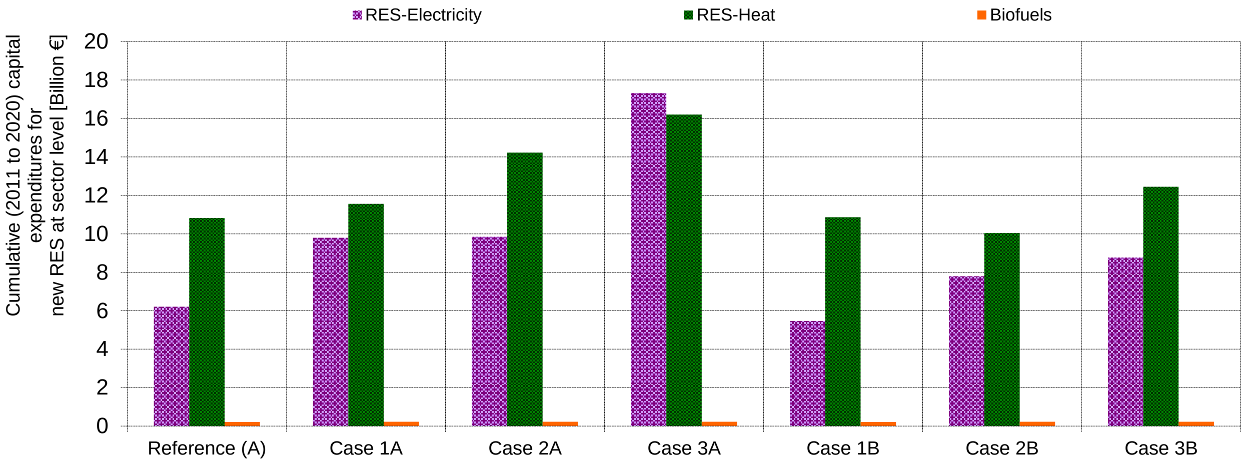

Figure 12: **Comparison of the required capital expenditures per sector for new (2011 to 2020) RES installations in Austria for all assessed cases**

Required support expenditures- sectoral level

RES-H requires in general less support than RES-E. This can be seen in Figure 13 where cumulative (2011 – 2020) support expenditures for new RES installations are illustrated by sector. More precisely, support expenditures are higher for RES-E compared to RES-H in cases 1A, 3A, 2B, and 3B, while in case 2A case they are of similar magnitude in both sectors. Figure 13 below also includes potential earnings (-) or expenditures (+) arising from the use of RES cooperation mechanisms next to the cumulative (2011 to 2020) support expenditures for new RES installations at sector level. The prices used in our assessment vary depending on the scenario and the year in which the trade occurs (see Annex 1, Table 17) for the negotiated exchange price per MWh RES generation for (virtual) RES trade for each scenario).

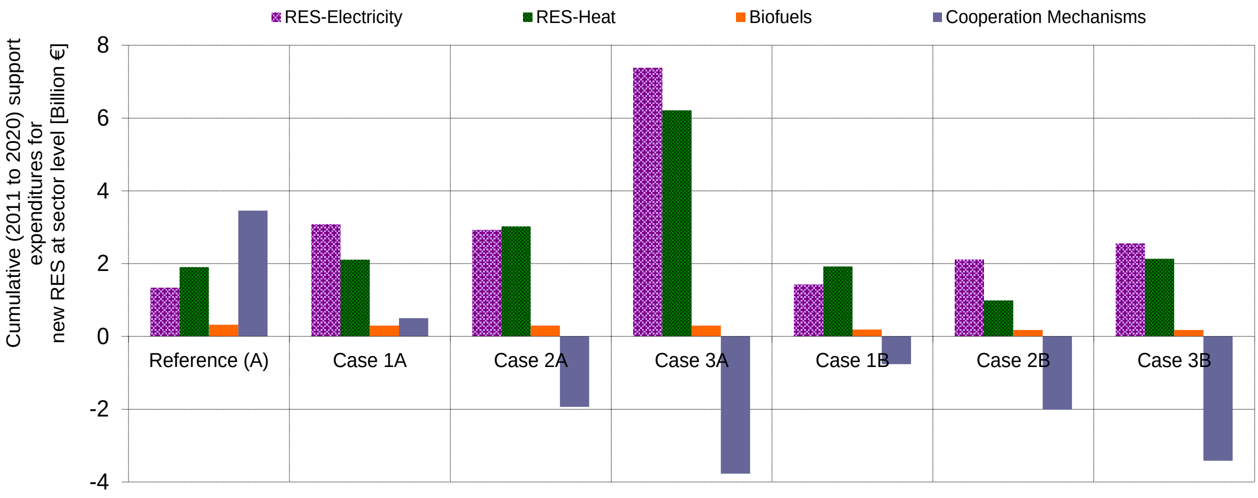

Figure 13: **Comparison of the required cumulative support expenditures for new (2011 to 2020) RES installations in Austria for all assessed cases** (part 1 – sector breakdown)

As can be seen, benefits from selling the surplus of RES to other EU Member States occur as expected in cases of over fulfilment (cases 3A and 3B), but also in cases 2A and 2B where an exact RES target fulfilment is conditioned for 2020 or even in case 1B where net RES imports are required by 2020. In these cases the benefits arise in the timespan prior to 2020 where the RES deployment is well above the minimum RES trajectory and RES shares can be sold.

Support expenditures at the aggregated level

Subsequently we take a closer look on support expenditures at the aggregated level. Thereby, we illustrate in particular the impact of an intensified use of cooperation mechanisms. In this context, Figure 14 offers a comparison of the required cumulative (2011 to 2020) support expenditures for all RES sectors and shows expenditures and revenues from using the RES cooperation mechanisms for all scenarios.

In cases 1A and 1B, which represent the calculated variants for a non-fulfilling of the Austrian RES target, a **sensitivity analysis** is included. If most other EU Member States struggle to fulfill their proposed 2020 RES share targets, acquiring additional RES volumes through the cooperation mechanisms will become more expensive as a result of the supply shortage. The two additional cases for a high price scenario demonstrate the uncertainty related to the use of cooperation mechanisms, in particular related to price expectations. The high price case for 1A predicts additional costs of € 0.2 billion, whereas in case 1B higher prices for sold RES shares prior to 2020 would lower the costs of needed support expenditures by € 3.6 billion resulting in € 0.8 billions of benefits from (virtual) RES exports. As can be seen in this comparison, importing massive RES volumes by 2020 may represent a very costly policy option for Austria. Notably, uncertainty occurs not only with regard to the price, expectations on offered quantities are also highly speculative.

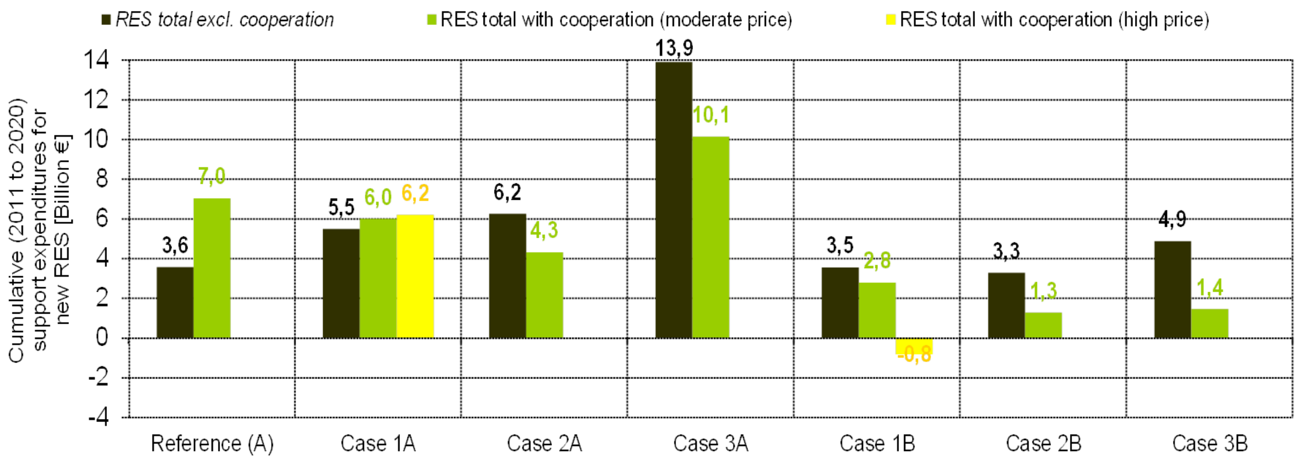

Figure 14: Comparison of the required support expenditures for new (2011 to 2020) RES installations in Austria for all assessed cases (part 2 – impact of cooperation)

Avoidance of CO2 emissions due to new RES installations

RES will contribute substantially to reduce CO_2 emissions in Austria's energy sector. The reference case projects an avoidance of 45.9 Mt CO_2 emissions due to new RES installations in the period 2011 to 2020 (see Figure 15). The strengthening of RES support in case 2A reduces CO_2 emissions additionally by 33.9 Mt compared to the reference case. The most ambitious case 3A realizes additional CO_2 emissions reductions by 52.7 Mt. The B cases with additional energy efficiency measures show lower figures of CO_2 avoidance as a result of lower RES deployment needed to reach the specific percentage goal of each scenario. Anyhow, Austria's CO_2 emissions are already reduced through energy efficiency measures in the B scenarios.

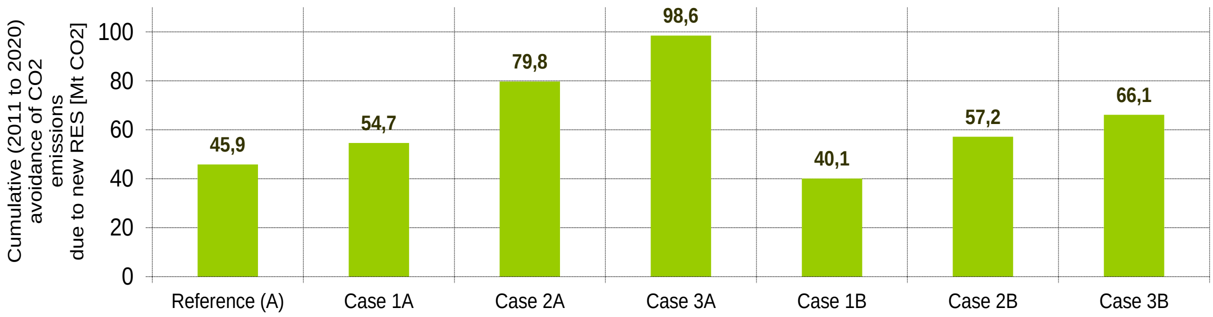

Figure 15: Comparison of the CO_2 avoidance due to new (2011 to 2020) RES installations in Austria for all assessed cases

Avoidance of carbon emission goes hand in hand with reduction of fossil fuel use for energy supply. Given the fact that Austria is largely dependent on imports of fossil fuels, an accelerated RES deployment will contribute significantly to increased domestic supply security. Fossil fuel savings are in the range of 4.4 to 9.9 billion € by 2020[12] (see Figure 16 for further details).

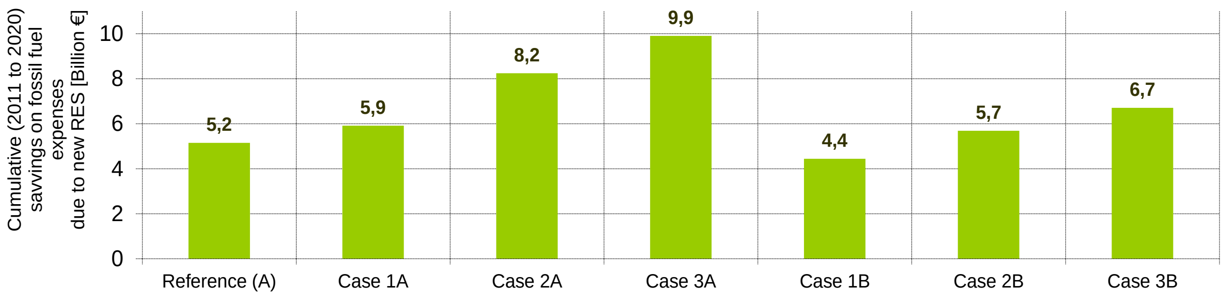

Figure 16: Comparison of the resulting avoidance of fossil fuel expenditures due to new (2011 to 2020) RES installations in Austria for all assessed cases

[12] The monetary expression of fossil fuel avoidance is based on an assumed international energy price development as taken from the PRIMES energy model (NTUA, 2009). More precisely, a so called "high price case" is used as reference for all calculations. According to this, the oil price for instance goes up to 100 $\$_{2005}$ per barrel, which is still significantly below past energy prices as observed throughout 2008.

3.3.3 RES trading between 2011 and 2020

Not only the 2020 RES targets have to be fulfilled by EU countries, but also interim targets (following an indicative trajectory defined in the RES directive) should be met. Although these interim targets are not binding they may create demand before the year 2020. Figure 17 and Figure 18 illustrate the development over time (i.e. from 2011 to 2020) for Austria with respect to RES volumes and feasible income from or expenditures for RES cooperation. More precisely, these figures illustrate the overall RES shares and the interim targets up to 2020 (following the RES minimum trajectory), illustrated by continuous lines for selected case). Additionally, the corresponding feasible yearly income (from selling the surplus above the minimum trajectory) or expenditures from buying virtual RES volumes on the cooperation market (necessary if RES deployment is below the given minimum trajectory) is illustrated (discontinuous lines). See Annex 1 for numerical values. The figures illustrate that Austria could sell interim surpluses in the upcoming years in all scenarios.

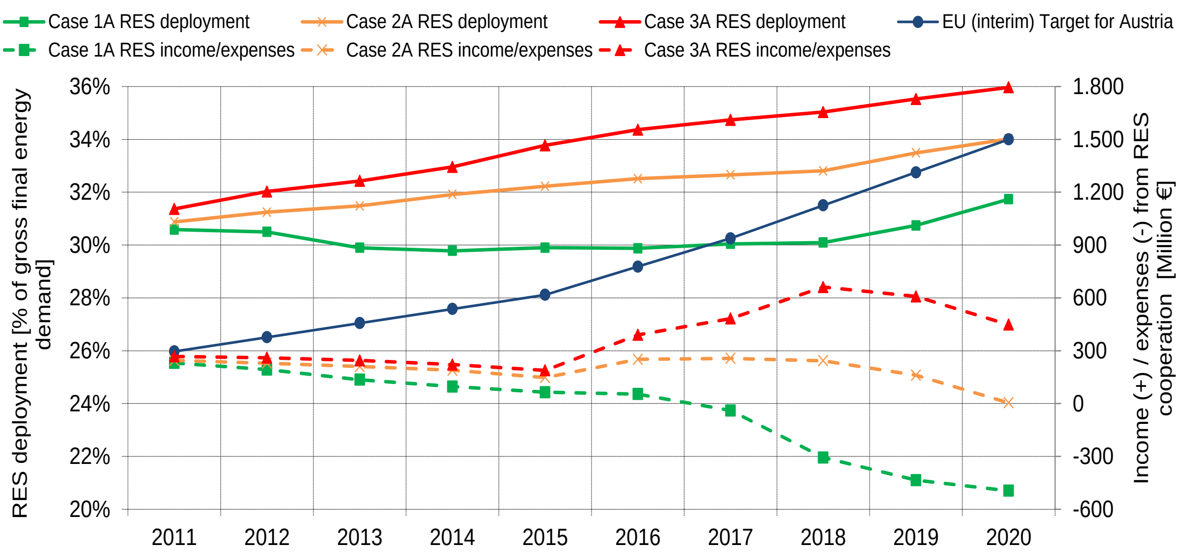

Figure 17: **RES trajectories up to 2020 and income from or expenditures for RES cooperation for A-Scenarios**

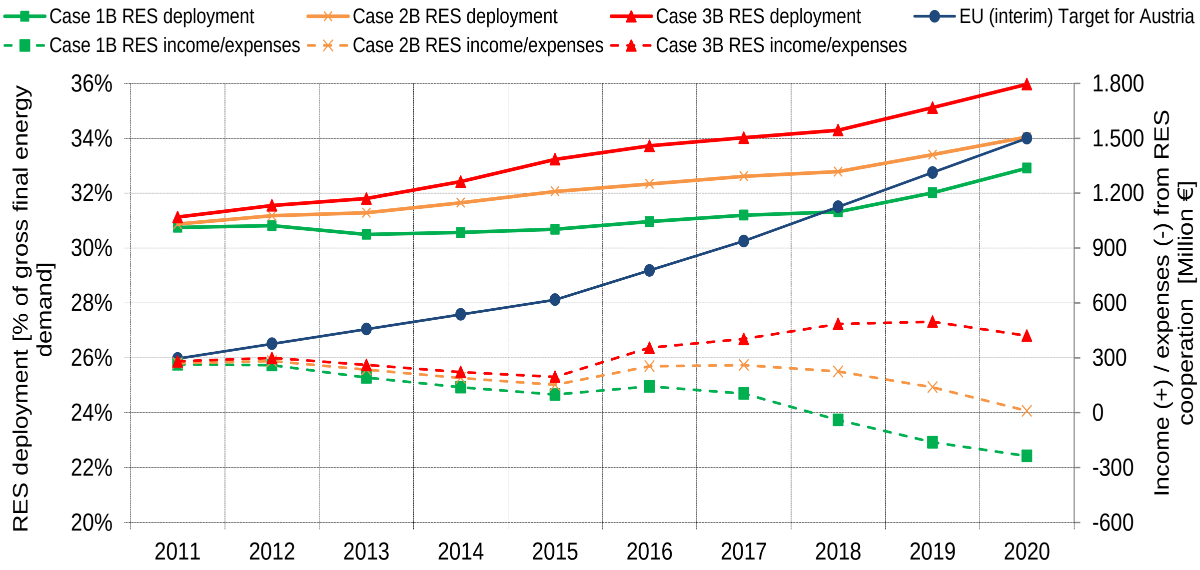

Figure 18: **RES trajectories up to 2020 and income from or expenditures for RES cooperation for B-Scenarios**

3.3.4 Scenario results – the European dimension

All researched policy cases are tailored to achieve the target of 20% RES by 2020 at the EU level. Moreover, for all cases (except the reference case) a removal of non-economic barriers (i.e. administrative deficiencies, grid access, etc.) is assumed for the future[13]. More precisely, a gradual removal of these deployment constraints, which allows an accelerated RES technology diffusion, is conditioned on the assumption that this process will begin in 2011.
The policy framework for biofuels in the transport sector is set equal under all assessed policy variants: an EU-wide trading regime based on physical trade of refined biofuels is assumed to assure an effective and efficient fulfilment of the country's requirement to achieve (at least) 10% RES in the transport sector by 2020. Thereby, second generation biofuels receive a sort of prioritization (i.e. a higher support given via higher weighting factors within the biofuel quota regime) in line with the rules defined in the RES directive. Other novel options in this respect such as e-mobility or hydrogen have not been assessed within this analysis as also no direct impact on the overall RES target fulfilment can be expected.

The characteristics of each assessed policy pathway are discussed subsequently:

- **Reference case:** RES policies are applied as currently implemented (without any adaptation) – until 2020, i.e. a business as usual (BAU) forecast. Under this scenario a modest RES deployment can be expected for the future up to 2020.
- **Reference case with mitigated non-economic barriers:** RES policies are in place as currently implemented including mitigation of non-economic barriers.
- **Strengthened national RES policies (Case 1A, 2A, 3A, 1B, 2B, 3B):** a continuation of national RES policies until 2020 is conditioned for this policy pathway, whereby the assumption is made that national RES support schemes will be further optimized in the future with regard to their effectiveness and efficiency in order to meet the 2020 RES commitments. In particular, the further fine-tuning of national support schemes involves in case of both (premium) feed-in tariff and quota systems a technology-specification of RES support. No change of the in prior chosen policy track is assumed – i.e. all countries which currently apply a feed-in tariff or quota system are assumed to use this type of support instrument also in the future.
  However in case of fixed feed-in tariffs a switch towards a premium system is conditioned to assure market compatibility as relevant with increasing shares of RES-E in the electricity market.[14]

[13] It can be concluded that a removal of non-economic RES barriers represents a necessity for meeting the 2020 RES commitment. Moreover, a mitigation of these constraints would also significantly increase the cost efficiency of RES support.

[14] In general, the process of strengthening of national RES policies for increasing their efficiency and effectiveness involves the following aspects: the provision of a stable planning horizon; a continuous RES policy/long-term RES targets; a clear and well defined tariff structure; yearly targets for RES-E deployment; a guaranteed but strictly limited duration of financial support; a fine-tuning of incentives to country-specific needs for the individual RES technologies; a dynamic adaptation/decrease of incentives in line with general market conditions (i.e. to incorporate the impact of changing energy and raw material prices) and specifically to stimulate technological progress and innovation.

The following sub-variants have been assessed:

- **"National perspective" – national target fulfilment (Case 1A, 2A, 1B, 2B):** Within this scenario each Member States tries to fulfil its national RES target by its own. The use of cooperation mechanisms as agreed in the RES Directive is reduced to a necessary minimum: For the exceptional case that a Member State would not possess sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a Member State possesses barely sufficient RES potentials, but their exploitation would cause significantly higher consumer expenditures compared to the EU average, cooperation would serve as complementary tool to ensure target achievement. As a consequence of above, the required RES support will differ comparatively strongly among the EU countries.
- **"European perspective" (3A, 3B):** In contrast to the "national perspective" case as described above, within this scenario the use of cooperation mechanisms does not represent the exceptional case: If a Member State would not possess sufficient potentials that can be economically[15] exploited, cooperation mechanisms would serve as a complementary option. Consequently, the main aim of the "EU perspective" scenario is to fulfil the 20% RES target at the EU level, rather than fulfilling each national RES target purely domestically. Generally, it reflects a 'least cost' strategy in terms of consumer expenditures due to RES support. In contrast to simple short-term least cost policy approaches, the applied technology-specification of RES support does however still allow an EU-wide well balanced RES portfolio.

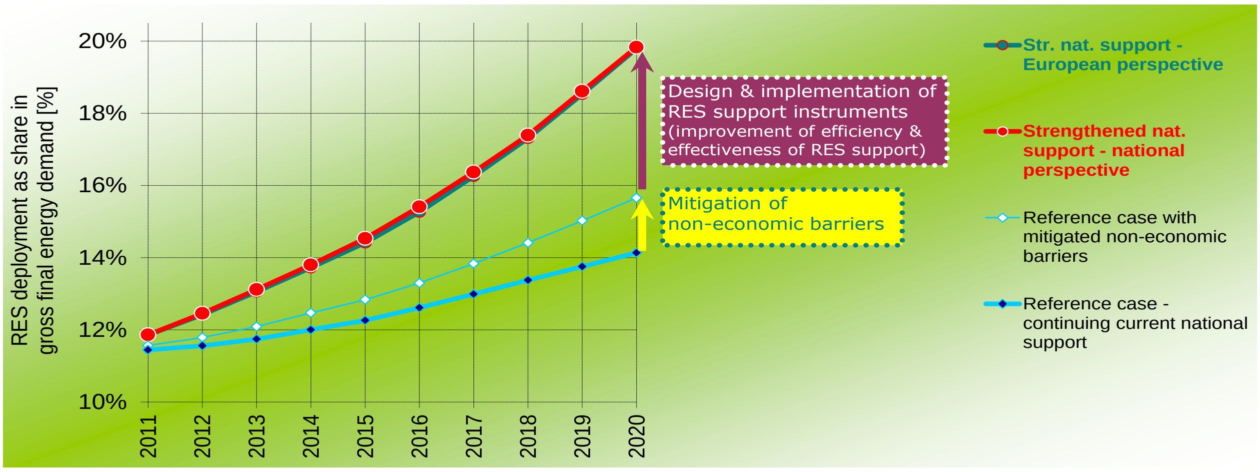

Figure 19: **Comparison of RES deployment up to 2020 at the European level according to different RES-policy scenarios.**

Source: Green-X, 2011 (RE-Shaping project)

[15] In the "European perspective" case economic restrictions are applied to limit differences in applied financial RES support among countries to an adequately low level – i.e. differences in country-specific support per MWh RES are limited to a maximum of 8 €/MWh RES while in the "national perspective" variant this feasible bandwidth is set to 20 €/MWh RES. Consequently, if support in a country with low RES potentials and/or an ambitious RES target exceeds the upper boundary, the remaining gap to its RES target would be covered in line with the flexibility regime as defined in the RES Directive via (virtual) imports from other countries. Moreover, in both variants a stronger alignment of support conditions between countries is presumed for wind energy and PV as for these technologies in the case of premium support a stepped tariff design is generally implemented, offering on the contrary a graduate differentiated support in dependence of the efficiency at the plant site (i.e. the site-specific full load hours). Such a system is currently implemented for example in Germany or France for wind onshore in order to trigger investments not only at best sites and to limit over support simultaneously.

Analysing Figure 19, two variants of the reference case and the "strengthened national policies" case indicate the impact of the individual key measures to move from a BAU to an enhanced RES deployment in line with 20% RES by 2020:

- Mitigation of non-economic RES barriers: Retaining current financial RES support but supplemented by a mitigation of non-economic deficits would allow a 2020 RES-E share of 29.2% (compared to 25.9% as default). The corresponding figure for RES in total is 15.7% (instead of 14.1% as default). A significant impact can be also observed for the corresponding yearly support expenditures due to RES-E support. Required expenditures by 2020 would increase substantially under the assumed retaining of current support conditions (without any further adaptation) – i.e. rising from about 50 to 72 billion € in 2020 for RES-E solely, while expenditures for RES in total increase from 74 to 98 billion € (see Table 3). This indicates the need to align support conditions to the expected/observed market development, as otherwise specifically novel RES technologies would achieve significant over support in case of future mass deployment.
- Design and implementation of RES support instruments: The detailed policy design has a significant impact on the RES deployment and corresponding expenditures, specifically for the electricity sector. This can be seen from the comparison of the "strengthened national policy" case with the BAU variant where similar framework conditions are applied (i.e. removed (non-economic) barriers and a moderate demand development). For RES-E the direct improvement of the efficiency and effectiveness of the underlying support instruments causes an increase of the RES-E share from 29.2% (BAU with removed barriers) to 36.4% ("strengthened national support – national perspective"). For RES in total the impact on deployment is of similar magnitude – i.e. an increase of the RES share of gross final energy consumption from 15.7% to 19.8% is observable. With respect to support expenditures the consequences are more significant for the electricity sector as then the required burden can be decreased substantially (while the deployment follows an opposite trend). More precisely, yearly expenditures in 2020 would decline from 72 to 63 billion € for RES-E, while for RES in total an insignificant increase is observable (i.e. from 98 to 105 billion € in 2020) (see Table 3).
- More intensified cooperation between Member States ("strengthened national support – European perspective") in achieving their 2020 RES targets would finally allow to reduce the cost burden while under the conditioned fulfillment of the 2020 RES target aggregated (at EU level) RES deployment would remain unaffected at the EU level – i.e. obviously, national RES deployment would differ[16]. Yearly support expenditures can be decreased by about 5% for RES-E, i.e. from 63 to 60 billion € in 2020 (see Table 3). For RES in total the impact is in magnitude of 4% for this specific policy path.

The key figures of the assessed and above explained cases are presented in Table 3. The reference case reaches 14.1% RES share in gross final energy consumption by 2020. Including mitigation of non-economic barriers results in a 15.7% RES deployment.

[16] Although RES deployment would remain unaffected at the EU level, national RES deployment would differ between both cases of strengthened national RES support (with more or less intensified cooperation between Member States).

Strengthened national support is needed to reach the EU 2020 target of a 20% RES in the gross final energy demand. The strengthened national support - national perspective case projects total support expenditures of € 105 billion by 2020. In the European perspective case with intensified cooperation to reach the 2020 RES target the total support expenditures by 2020 are reduced to € 101 billion by € 4 billion.

Table 3: **Key Figures on RES-E deployment by 2020 and corresponding support expenditures for researched cases** (from BAU to strengthened national support, from a national/European perspective) Source: Green-X, 2011 (RE-Shaping project)

Key Figures for researched cases - from BAU to strengthened national support			**Resulting deployment by 2020**		**Yearly support expenditures by 2020**	
Scenario		*Corresponding measures*	RES-E share in gross electricity demand [%]	RES share in gross final energy demand [%]	RES-E support [Bill.€]	Support for RES in total [Bill.€]
1	Reference case - continuing current national support		24.7%	14.1%	50	74
2	Reference case (moderate final energy demand & mitigated barriers)	*(1 --> 2) Mitigation of non-economic RES barriers*	29.2%	15.7%	72	98
3	Strengthened national support - national perspective	*(2 --> 3) Improvement of design and implementation of RES support instruments*	36.6%	19.8%	63	105
4	Strengthened national support - European perspective	*(3 --> 4) Intensified cooperation*	36.4%	19.8%	60	101

A closer look at the relevant performance indicators shows that improved energy policies could EU wide lead to:

- **Additional investments** of **462 billion Euros** in the overall period **2011 to 2020**.
- Above indicated investments would trigger about **3,014 PJ additional RES generation in** the year **2020.**
- An avoidance of **4,773 PJ** of **fossil primary energy use in 2020**.
- In last consequence about **341 million tonnes CO_2** can be avoided **in 2020** by an enhanced RES generation based on improved energy policies.

RES-E deployment by 2020 and corresponding consumer expenditures for researched cases

The average yearly consumer expenditures (2011-2020) due to RES support for new RES installations serves as a key indicator for the assessed European cases. The question is how the cost burden for the consumer of the strengthened national support compares in the national and European perspective. Figure 20 shows that average yearly consumer expenditures decrease in the European perspective case compared to the national perspective case of strengthened national support. This would speak for more cooperation between EU Member States to fulfill their RES targets compared to national fulfillment only.

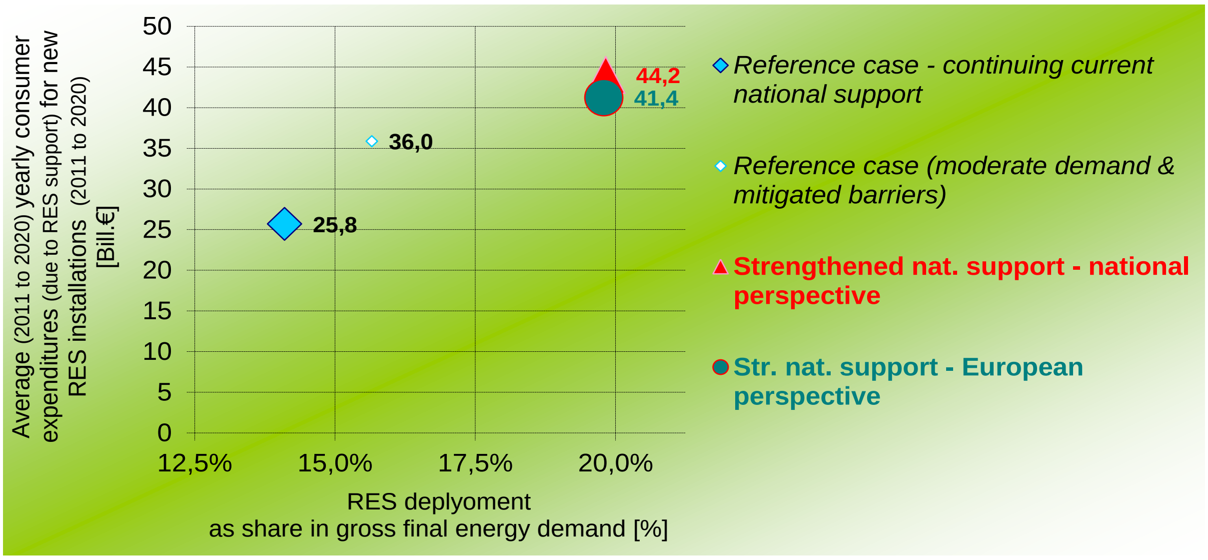

Figure 20: Comparison of the resulting 2020 RES deployment and the corresponding (yearly average) consumer expenditures due to RES support for new RES (installed 2011 to 2020) in the EU-27 for selected cases[17]

Figure 21 depicts the two assessed European cases for strengthened national support on the national level. The (virtual) exchanges of RES volumes by 2020 due to cooperation mechanism are plotted for all EU Member States for both cases. The Green-X model calculates 2.7 TWh of (virtually) exported RES volumes by 2020 in the national perspective case for Austria, whereas 6.7 TWh are (virtually) exported in the European perspective case. In other words, this indicates that for achieving the RES target of 20% RES by 2020 from a European perspective it appears beneficial from an economic viewpoint (i.e. considering support expenditures as decisive indicator) that Austria does more than required. Consequently, Austria could then virtually sell the surplus in RES deployment to other countries facing a deficit.

[17] i.e. BAU and strengthened national support without (national perspective) or with intensified cooperation (European perspective) between member states

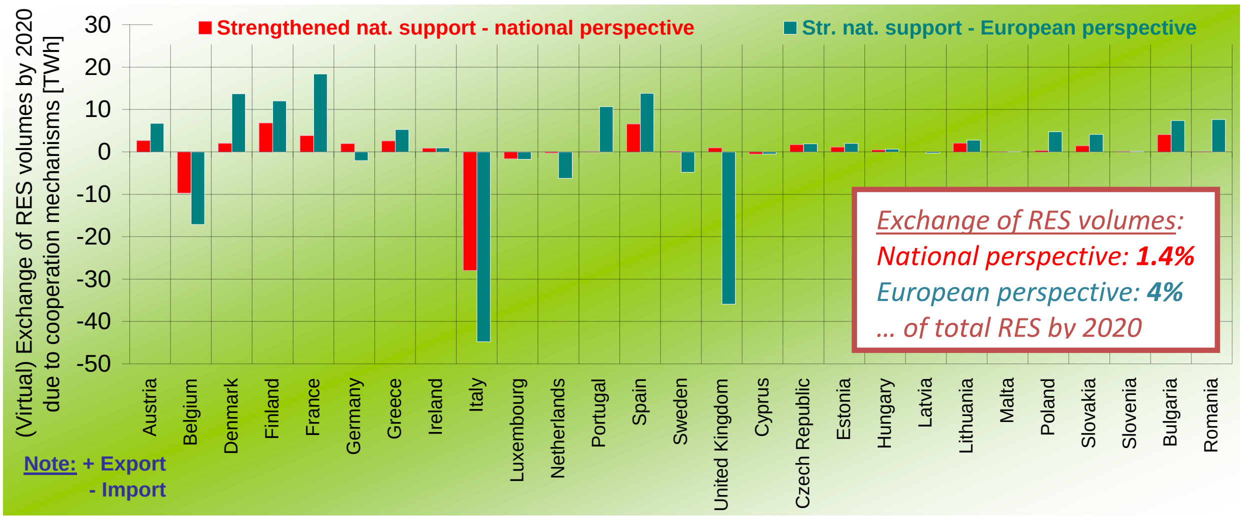

Figure 21: **The need for cooperation – (virtual) exchange of RES volumes by 2020 for selected cases** – i.e. strengthened national support without (national perspective) or with intensified cooperation (European perspective) between member states

Uncertainties regarding prices to which virtual RES volumes will be sold in the future may be a reason for too little incentives for over fulfillment for some EU Member States at present. From an EU perspective Austria however would be a country with relatively cheap options for over fulfilling its RES target and therefore should be encouraged by the RES cooperation mechanisms to do so.

4 Macroeconomic Evaluation and External Effects

This chapter describes the two components of economic well-being that are affected by measures for achieving the Austrian RES-target. These two components are economic effects displayed on markets (macroeconomic effects) and effects not displayed on markets ("external effects"). After discussing those two economic components separately in detail, the combination of both will be considered in the overall assessment of chapter 6.

4.1 Macroeconomic Effects

The scenario results of the Green-X model (chapter 3) provide data on costs of RES-expansion per technology (depending on the specific scenario). The Green-X model takes into account the microeconomic view of the investors as well as the macroeconomic view of the financial transfers (subsidies) needed to enable the investments. Nevertheless, Green-X doesn't consider that costs for RES-capacity extension or investments in energy efficiency measures (EEM) influence the prices of other economic inputs and output commodities, i.e. economic feedback effects are not taken into account. Energy is an important input factor for many production sectors and it is unlikely that prices across sectors stay unaffected. An extension of the RES-capacities is expected to be a significant intervention in Austria's economic framework that changes prices, trade flows, tax incomes and employment.

To take into account an adapting economic environment, an existing computable general equilibrium model (CGE-model) was modified to be used in a comparative static analysis[18]. The objective of the CGE-analysis is to gain insights into the total macroeconomic effects resulting from RES-expansion as well as from additional[19] energy efficiency measures, and to what extent feedback effects are reducing or increasing the first-round costs (investment and operating cost data gained by Green-X including subsidies, see chapter 3) of achieving a higher RES-share and thereby influence consumer welfare. Amongst others this CGE-analysis gives information on the effects in terms of welfare, foreign trade, employment and sectoral economic activity.

[18] Comparative static means that the comparison of the calculated static equilibrium is used for the evaluation of the scenarios. In this context static equilibria are macroeconomic equilibrium states after the process of adjustment.

[19] Additional refers to "additional to the reference scenario"

4.1.1 The macroeconomic model

As mentioned, the expansion of RES and the implementation of additional energy efficiency measures (EEM) may have a noticeable effect on the whole economy. To estimate such effects CGE-models are used since these models consider interconnections and dependencies of the sectors in an economy, the elasticities of substitution between different commodities in production and imports as well as the foreign trade and deadweight losses[20] caused by subsidies. Thereby they evaluate changes in the entire economic system. In case of energy consumption welfare is gained by the consumption of energy services[21] not by the physical consumption of energy itself. In this context a reduction of physical energy consumption due to energy efficiency measures does not reduce welfare. CGE-models are also able to macroeconomically evaluate technologies in a bottom-up approach by using information about their detailed cost structure[22].

Model description- the EnergClim-model

For this project an existing CGE-model and the underlying database have been adapted and advanced to be able to process RES-expansion as well as the implementation of EEMs in Austria. Additionally, data from other projects[23] were integrated, if they supplied necessary external inputs. RES-trade via the cooperation mechanisms was not considered separately, since it was considered by the Green-X-model already and is therefore already part of the input data for the economic modeling. The model applied is an extension of a CGE-model that has been developed by the Wegener Center (University of Graz) within the project "EnergClim[24]". The used computing tool was the program GAMS[25] with its specific programming language MPSGE[26]. The original purpose was to examine the use of various biomass based energy technologies in Austria within a global context. To analyze the global interconnection between states and regions it was necessary to use a global database. Therefore the GTAP 7 database of the Center for Global Trade Analysis (Purdue University) was used for the CGE-model[27]. This fairly advanced data set contains data from 113 regions and 57 economic sectors (with the base year 2004 in the most recent version). To put the data in a suitable form it has been remodeled within the EnergClim project to gain so called consistent "Social Accounting Matrixes" (SAMs), which are typically used as input for CGE-models. The regions were aggregated to 9 world regions with Austria as separate region. Additionally the economic sectors were merged into 15 sectors with 5 of them being energy related sectors (electricity, natural gas, crude oil, coal and petrol & coal products). Furthermore the consumption of fossil based energy services (e.g. space heat and transport) have been modeled as additional economic sectors in the SAM of the EnergClim model. This was

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[20] Deadweight loss or „excess burden“ is the loss of economic efficiency in allocation of goods on a market by taxes or subsidies.

[21] Energy services like a cubature kept at a certain temperature level for a particular time, access to people or goods (by transport)

[22] Cost structures of the RES-technologies were calculated in WP2 (chapter 2)

[23] Project „EnergyTransition“; Project „EISERN “Energieinvestitionsstrategien und langfristige Anforderungen zur Emissionsreduktion“ - project lead: TU Wien. A Project funded by the Austrian Energy and Climate fund.

[24] Energ.Clim- Energy supply from agricultural and forestry products

in Austria considering the climate and global change in 2020 and 2040

[25] General Algebraic Modelling Systems (GAMS)

[26] Mathematical programming system for general equilibrium analysis (MPSGE)

[27] GTAP=Global Trade Analysis Project

necessary in order to simulate changes in the economy's demand structure due to increasing renewable energy services that substitute their fossil counterpart. In the scenarios these fossil energy service producing sectors compete with the renewable based energy services.

Modification of the EnergClim-model

Since the focus in this project was on the effects of additional RES expansion and additional EEM on the Austrian economy the amount of regions has been reduced to 4, three European regions, Austria as an individual region complemented by one Rest-of-World region.

For the purpose of a detailed assessment of macroeconomic effects in the energy sector the separate analysis of effects on bundles of energy consumption commodities has been improved compared to the EnergClim model: To be able to process the Green-X data, the bundle of fossil based heat (on-grid and off-grid) and transport fuel needed to include not only the demand of private households, but also the demand of the production sectors. Model improvements carried out within this project allow the total energy demand of the economy to be represented in the CGE-model (as monetary values). On the production side the RES-expansion in the CGE-model has been split into investment and operation & maintenance (O&M) costs to integrate the results of Green-X in more detail. Investments in RES and in EEM are treated differently in the CGE-model. On one hand the investments in RES are treated like regular capital investments into energy production, hence this implies just a shift within the investments in the energy sector towards RES. Investments in EEM on the other hand are additional investments that go along with a shift from consumption to investments. EEM therefore lead to a reduction of consumption of the private households and the government (in the short-run).The actual RES production is represented by costs and cost structures of Operation and Maintenance (O&M) where the produced RES energy commodities substitute their respective fossil based counterparts.

Introducing new policies into the model

A common way to simulate a set of political measures in a comparative-static CGE-framework is to disturb the market equilibrium of the base year by introducing new policy incentives according to the scenarios defined in chapter 3. The algorithm calculates a new general equilibrium on all markets[28] by adjusting prices and quantities. The result takes into account direct and feedback effects of these measures relative to the base year equilibrium. In this project, we implemented additional measures every year over a 10-year period up to 2020. Therefore the CGE-Model applied in this project has been implemented by means of a recursive loop where the RES-expansion (investments and O&M costs) and the efficiency measures (investments and savings) are implemented every year. The levels of expansion of RES-technologies introduced in the model correspond to the input data from Green-X. The level of additional energy efficiency is in the same magnitude as the "efficiency case" of the Austrian NREAP, while the cost structure for additional EEM is taken from the project EnergyTransition (WIFO, 2011). Within the model runs an annual calculated general equilibrium is the base equilibrium for the subsequent year. The model has been calibrated to a reference growth path, i.e. the development until 2050 without additional RES or EEM. This

[28] On the factor markets and all sectoral commodity markets

means that the growth of the Austrian economy was modeled in a way to achieve an approximate real growth rate of 2% in GDP per year in the Reference case by adjusting the development of the capital stock and total factor productivity of the EnergClim-Model.

Application of CGE in the time range 2020-2050

In analogy to the Green-X scenarios and the analysis of Energy Transition (WIFO 2011), all investments needed to achieve the 2020 RES-target, are taking place in the period until 2020. As effects from investments in RES-expansion and energy efficiency implemented between 2011 and 2020 mostly last also for the period after 2020 an expansion of the time range for considering effects until 2050 was necessary. Nevertheless, this project's main focus is the evaluation of the investments until 2020. Therefore, follow-up investments of RES and EEM beyond 2020 are ignored and solely the long-term effects of the investments before and up to 2020 are evaluated. For this expansion of the considered time horizon – how investments undertaken by 2020 impact up until 2050 – several steps were needed. First, in each scenario, the number of recursive loops was increased to reach until 2050. Thereby the previous mentioned baseline growth was continued. Second, the economic lifetime of each RES-technology and EEM had to be determined. The RES energy production as well as the energy savings in each scenario and each technology decreased respectively according to their lifetime until 2050. Thirdly, expiring RES-technology subsidies have been considered in the model. This means, that additional generation costs are not covered by subsidies over the whole lifetime of the technology. And finally all external input data[29] needed to be extended to 2050. In the CGE-model the mentioned economic baseline growth is simplified and is caused by a change in available labor force, capital stock and total factor productivity. The last component covers technical improvements, but nevertheless the model assumes that economic growth still leads to an increasing energy demand after 2020 in the reference scenario[30]. However, the energy production from renewables and the energy savings of these investments stay active also after 2020 until the end of their economic lifetimes. Intensified EEM can stabilize energy demand for a certain period, however it is assumed in the model that after the technical life of EEM implemented in the period 2011-2020 energy demand converges to the level of the reference scenario once again. Additional RES-expansion shrinks the energy demand covered by fossil energy sources, but does not reduce the energy demand by itself.

Input data

To get a comprehensive view of the economy, a range of external input data was used. In the following a short description of use and source of this data is given.

Energy efficiency measures

The costs of energy efficiency measures (EEM) are based upon the results of the project EnergyTransition (WIFO, 2011). This report includes detailed descriptions of efficiency measures for Austria in the sectors transport, production and buildings. A sectoral investment input structure as well as an approximate monetary value of the energy savings was extracted thereof. Investments with this cost structure are activated yearly up until 2020 and are enabled

[29] Import prices of fossil energy commodities, taxes for CO_2 emissions
[30] Note: The planned EU Energy Efficiency directive may stabilize or reduce energy consumption in the long-term

by a reduction in private and public consumption. The energy savings from the EEM linearly increase until 2020 and thereafter decrease respectively according to the estimated lifetimes of the measures.

CO_2 Prices

In addition to economic data the GTAP 7 database contains also data on sectoral CO_2 emissions. The EnergClim-model used this data to link the used input of fossil fuels in the economic sectors to CO_2 emissions. The CGE-model adopted this method because it makes it possible to model a imposed tax per ton CO_2 input of the energy intense sectors (ETS). The magnitude of this tax was based upon data from the project EISERN[31]. The revenues of this tax are transferred in the model to the regional household[32]. Climate policy leads to increasing prices of CO_2-intensive commodities and also to a reduction in welfare due to the deadweight loss of the tax. This negative effect is highest in the Reference case. That means that the expansion of RES and the installation of EEM decreases this welfare loss when the energy production (and implied CO_2 emissions) from fossil fuels shrinks in all scenarios.

Labor market

An additional important factor for growth and welfare is the labor market. In the EnergClim-Model unemployment is included (non-clearance of the labor market; according to reality that unemployment exists). The neoclassical assumption hereby is that minimum wages requested by the labor force are too high for the market to be in equilibrium clearance. With an increasing demand for labor – and consequently rising wages – labor employed increases and new factor incomes are generated. In the Reference case the unemployment rate is fixed to an approximated 2010 level of 5%. The effect on employment differs across scenarios since the RES-technologies and EEM investments affect the labor market differently. Therefore the scenario effects on the labor market depend on the mix of RES-technologies and EEM.

Energy Prices

The third important inputs for the model are price assumptions for fossil fuels and resulting prices of the energy generated. Rising energy prices influence the modeling of the scenarios in two ways. Firstly, rising energy prices increase the positive effects of the decreased imports of fossil fuels. Secondly, they increase the reference price and thereby improve the competitiveness of RES-installations.

[31] Projekt EISERN – „Energieinvestitionsstrategien und langfristige Anforderungen zur Emissionsreduktion" - project lead: TU Wien. A Project funded by the Austrian Energy and Climate fund. EISERN bases its data on projections by the IEA.

[32] Regional household stands for the government and private households

Table 4: Sources of energy price data

		For the period 2011-2020	For the period 2020-2050
Energy prices	Electricity, Transport fuel, Heat (on-grid, off-grid)	Green-X	• PRIMES (2009) • EISERN[33] (fossil fuel prices)
Fossil fuel prices	Coal, Crude oil, Natural gas	Green-X	• EISERN[34] (fossil fuel prices)

Table 4 gives an overview of sources for energy price assumptions used in the CGE-model. For 2011-2020 energy prices as well as fossil fuel prices were used according to Green-X data. For the period after 2020 data from other projects were combined in two steps. The first step was to estimate fossil fuel prices. For this purpose the forecasted growth of fossil fuels from the project EISERN was used to extrapolate the assumed prices of the Green-X model. The second step was to use these estimated fossil fuel prices and combine them with the shares of fossil fuels in the future energy production in transport, heat and electricity. These shares were taken from the PRIMES 2009 forecasts (which include a forecast until 2030). The shares were kept at the same level for the period after 2030.

4.1.2 Results of the macroeconomic modeling

This section displays and discusses the macroeconomic results of the six scenario simulations (for scenario definition see chapter 3). These reflect the impact of the scenario assumptions on the whole economy and are displayed as deviations from the reference case. Future costs and revenues were discounted at a rate of 2.5% p.a.. A main result of the macroeconomic modeling is the effect on consumption[35]. In this model the consumption does not only include the consumption of goods and services, but also the value of saved energy due to previous investments in EEM. Using this approach, consumption serves as an index for macroeconomic welfare[36]. In other words, using saved energy costs (e.g. due to lower heating demand resulting from increased insulation) additionally to a constant consumption level represents an increase in welfare since more commodities as well as the heat can be consumed. The saved energy is valuated by the energy prices (e.g. €/kWh for space heating) in the model. Therefore a net increase (decrease) in consumption means a higher (lower) level of welfare.
Subsequently in this chapter results for the short-term and the long-term view are discussed. The time horizon until 2020 is denominated as short-term view since the economic lifetime of RES-technologies and especially EEM-investments[37] is up to 40 years and thus much longer. The long-term view considers the developments until 2050 when the economic lifetimes of most investments have ended.

[33] Project EISERN – „Energieinvestitionsstrategien und langfristige Anforderungen zur Emissionsreduktion" - project lead: TU Wien. A Project funded by the Austrian Energy and Climate fund. EISERN bases its data on projections by the IEA.
[34] Ibid
[35] Based on a demand function with constant elasticities of substitution
[36] Macroeconomic welfare is a level of utility that is gained by consumption of goods and services
[37] E.g. hydro power and passive houses

Results for the short term perspective until 2020

According to the scenario definitions all capital investments in RES and EEM are made in the time period until 2020, thereby achieving the respective RES-share levels of each scenario. The production of energy is based on RES increases according to the results from Green-X. This increase in the RES-shares for energy generation causes economic effects due to structural changes of the energy supply structure as well as respective prices, as renewable energy generation partly demands other inputs (technology specific input structure) than fossil-based energy production.

The results include three main components:

- **Consumption.** Consumption represents the welfare of the society.
- **Trade balance**. The trade balance expresses the difference between the values of imported and exported commodities. It is crucial to understand that the level of consumption is connected to the trade balance as it affects the import of commodities. If increasing consumption is requiring increasing imports, and this is not accompanied by a rise in exports, it results in a trade balance deficit which is financed by foreign depts.
- **Gross fixed capital investments.** The investments lead to changes in the economy's capital stock over time.

Table 5 summarizes the effects on central macroeconomic parameters as monetary deviations from the reference case and accumulated over the 10-year period 2011-2020.

Table 5: Accumulated results of macroeconomic effects until 2020 (2.5% discount rate)

	Consumption cum. 2011 - 2020	Gross fixed capital investments cum. 2011-2020	Foreign Trade Balance cum. 2011-2020
	Mio € compared to Reference Scenario – discounted		
1 A	-975	-740	-1.038
2 A	754	-31	-2.988
3 A	431	2.993	-5.585
1 B	-36.640	38.680	1.131
2 B	-37.473	37.364	1.571
3 B	-36.075	38.383	-381

The effects on consumption in the A-scenarios differ in prefix but considering that they represent accumulated numbers for a 10-year period they are relatively small. Even though the consumption in 2A and 3A is positive it can be seen that consumption effects are overcompensated by increased net imports financed by foreign creditors. The reasons for this are twofold. First, some RES-technologies (especially PV) need commodities (such as technical components) with high import shares. Therefore an increase in RES-production in these technologies leads to a higher demand for imports. Second, the installation of noncompetitive RES-technologies[38] leads to increased energy prices. Since energy is an input in all sectors of the economy the domestic price level rises compared to other regions. This in turn leads to a reduced demand for domestic exports while increasing the demand for – relative – cheaper imports from abroad. An opposite effect arises from decreased demand for the increasingly expensive fossil fuels, but it can't outweigh the tendencies for negative trade balance effects in the A-scenarios.

The B-scenarios show a quite different picture. Adjusted data[39] from the EnergyTransition (WIFO 2011) project show, that the needed expenses on EEM are about €46 billion over the considered 10-year period. The investments in EEM are additional investments to the yearly economic gross fixed capital formation[40]. Since funds generally available in the economy are either used for consumption or investments these additional investments (€46 billion) consequently lead to a reduction in consumption during the investment period. Taking this into account it is obvious that EEM have a major influence on the overall consumption (and welfare) in the short term. As displayed in Table 5 by highly negative consumption in the B-scenarios within the period 2011-2020, a transfer of funds from consumption towards capital investment takes place. This of course leads to a higher capital stock (see gross fixed capital investments in Table 5). These investments in energy efficiency pay off in form of energy savings. The payoff of the investments (in form of saved energy expenses) occurs over a long term period along the lifetimes of the technologies/investments. Until 2020 these payoffs do not prevail, i.e. do not compensate the investment costs.
Unlike in the A-Scenarios, the trade balance is almost balanced or even positive for the B-Scenarios. This has two reasons. First, due to only moderate RES-capacity expansion in all B-scenarios only a small impact on imports occurs. The second reason is that EEMs mainly demand commodities that have a low import rate (e.g. construction services).

Development of consumption over time
For a better understanding of the results it is useful to have a look at the development of consumption over time. (The trade balance effects over time until 2020 and the macroeconomic effects of single technologies can be found in Annex 2).

[38] The generation of RES-energy is more expensive relative to the reference generation costs of the respective energy form (Heat, Electricity or transport fuel). These additional generation costs were calculated by the Green-X model.
[39] The data from the Energy Transition contains packages of energy efficiency projects in Austria. The data was adjusted to meet a reduction in final energy consumption of 150 PJ by 2020.
[40] The macroeconomic expression for the total capital investments of an economy within one year

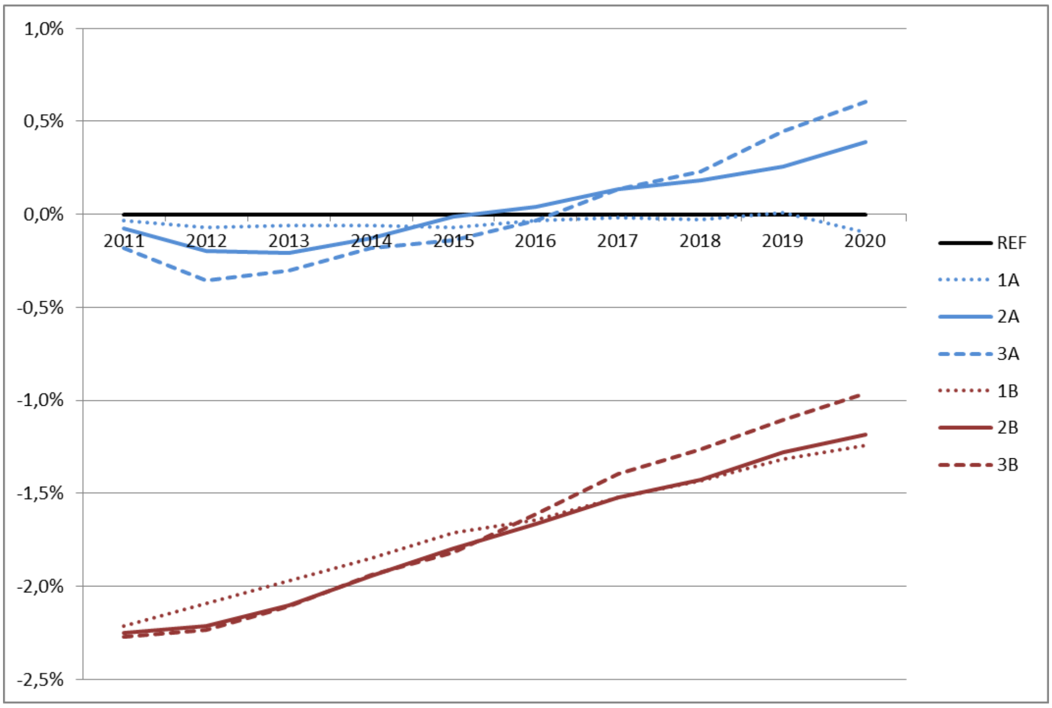

Figure 22: Deviation of consumption relative to the reference case

The results of the A-scenarios in Figure 22 show a (compared to the reference case) relatively lower consumption level within the first years and an increase towards 2020 in case 2A and 3A. The reasons for this deviation compared to the reference case are twofold: on the one hand the negative effects are caused by accelerating the expansion of non-competitive and therefore relatively expensive RES-technologies and by the deadweight loss due to the necessary subsidies granted for RES-technologies[41]. On the other hand the positive effects are caused by increased domestic employment, a higher capital stock of RES-facilities and therefore higher amounts of return on investment for consumption uses as well as the reduction of the increasingly expensive imports of fossil fuels.

Along the B-scenarios it is easy to see that the effects of the reduction in consumption due to investments in EEM dominate up to 2020. Figure 22 shows that the consumption in the B-scenarios is clearly below the reference consumption. Nevertheless, the consumption growth in the B-Scenarios is stronger than in the A-scenarios. The reason for that is that funds, formerly used for energy consumption, due to increased energy efficiency gradually becomes available to a bigger extent for other consumption purposes. This increases in the long run the consumption possibilities as beside higher consumption the same energy service (e.g. warm houses) can still be consumed – but just at smaller costs. This long-term increase in consumption possibilities increases also the welfare. However, before getting this benefits energy efficiency investments have to be financed. For that the government and the private households would need to reduce their total consumption at an average of 1.7% per year in the time period until 2020 to reach the level of energy savings according to the ReFlex Efficiency Scenario.

[41] Deadweight loss or „excess burden“ is the loss of economic efficiency in allocation of goods on a market by taxes or subsidies.

To conclude the view until 2020: The B-scenarios lead to a high reduction in consumption (in the short run), a higher capital stock and have small negative or positive effects on the trade balance. In the A-scenarios consumption remains relatively constant while imports increase in all A-scenario cases.

Scenario results for the time until 2050

The view until 2020 is insufficient to compare the outcomes of the scenarios since the pay-off of the EEM occurs over a long period of time[42]. Therefore the period under investigation has been expanded up to 2050. The view until 2050 includes all the long-term payoffs of the investments that have taken place until 2020. These payoffs are energy savings, less import of expensive fossil fuels, higher employment and the capital rent from the RES installations. This view – including the whole lifetime of most of the installed technologies – allows evaluating the total long-term effects on welfare of investments, of the production of renewable energy and of energy savings.

[42] Up to 40 years in case of passive houses or thermal rehabilitation

Table 6: Accumulated results of macroeconomic effects until 2050 (2.5% discount rate)

	Consumption cum. 2011 - 2050	**Gross fixed capital investments cum. 2011-2050**	**Foreign Trade Balance cum. 2011-2050**
	M€ compared to Reference Scenario - discounted		
1 A	3.053	530	-4.433
2 A	12.434	3.656	-8.612
3 A	18.762	8.776	-15.990
1 B	-1.710	39.400	806
2 B	-2.611	38.064	1.485
3 B	8.185	42.031	-5.212

The outcome of all A-Scenarios – as shown in Table 6 – is a strong increase in welfare; however there are strong negative effects on the trade balance. In particular in 2A and 3A there are strong positive welfare effects compared to the short term view (compare with Table 5).

In contrast, the reduction in consumption in the B-scenarios– due to the EEM investments until 2020 – is far lower than in the short term view. However, the highly negative consumption in the short-term view is compensated by positive effects (energy cost savings, return on capital) only in 3B that has positive welfare effects up to 2050 as positive effects and feedback effects[43] prevail. Case 1B and 2B show a negative total deviation in consumption when applying a discount rate of 2.5% up to 2050. The foreign trade balance in the B-scenarios shows a similar picture as the results until 2020: a small but positive effect on foreign trade balance in the cases 1B and 2B, while the moderate expansion of RES-support in 3B leads to a negative effect.

The results regarding gross fixed capital investments among all scenarios differ from the results until 2020. The capital investments – and thereby the capital stock – increases noticeable in the cases of moderate and strong expansion of RES capacities (i.e. 2A, 3A and 3B) as well as in cases of increased energy efficiency (B-scenarios). This sketches the complex effect of the expansion of RES capacities. The higher domestic energy production increases the domestic value added. That is partly compensated by imports, but still leads to higher demand for labor, which leads consequently to more revenues available for consumption, savings and investments and thereby to an increasing capital stock and – once again – factor (labor, capital) incomes.

[43] i.e. a higher disposable income, a higher demand for labor and thereby a higher employment rate leading to higher economic growth and capital investments what again leads to more factor income, more demand for goods and labor.

Development of consumption over time

The view on the development of consumption over time in Figure 23 gives a better understanding of the effects of the different scenarios (The trade balance effect over time until 2050 can be seen in Annex 2)

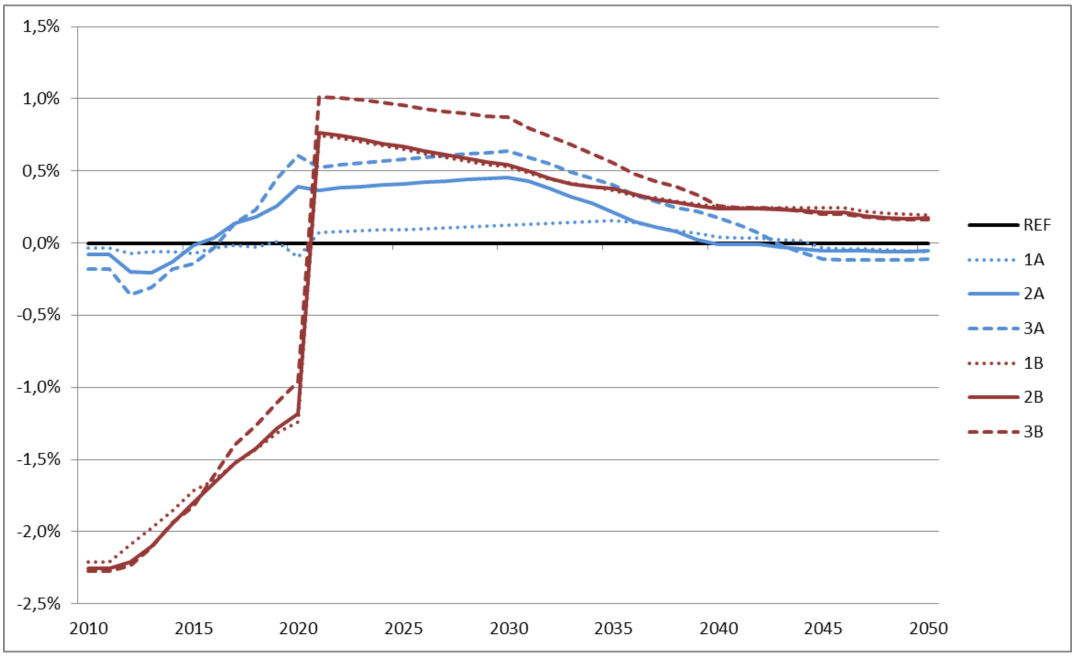

Figure 23: Deviation of consumption relative to the reference case (2010-2050)

The A-scenarios show a continuation of the positive development of welfare until 2020. The positive effects go along with the lifetimes of the RES-installations and decrease towards 2050. In case of 3A it can be seen that this case – with the strongest RES-expansion – leads initially to the strongest decrease in consumption (due to high investment needs, dead weight loss due to subsidies, utilization of relatively costly technologies compared to 1A and 2A) but has the most positive long lasting deviations after 2020.

The end of the (in the model assumed) investment period of the B-scenarios in 2020 can clearly be seen as a sharp increase in consumption as the investments in EEM end in our analysis.[44] After 2020 the consumption is in all B-scenarios higher than in the reference case. There are several reasons for this effect. First, the reduced import of increasingly expensive fossil fuels benefits the local economy. The second reason comes from the higher employment rate and hence higher level of income in all scenarios. This higher income level – and the additional disposable income due to energy savings – leads not only to higher consumption but also to economic growth. Since investments are linked to economic growth, this leads to more investments, which is the third reason for increased welfare. These additional investments lead to a higher capital stock and hence to a higher factor income (i.e. rents). Also, the B-scenarios have a higher consumption level than the A-scenarios in 2050. This is because some EEMs, like thermal refurbishment and passive house standards, have an assumed economic lifetime of 40 years and generate energy savings until 2050. This emphasizes the need for long-term consideration of EEMs as they pay-off only in the long

[44] As only the effects from investments until 2020 are intended to be modeled. Of course, in reality investments in renewable energies and energy efficiency will go also beyond 2020.

term. Nevertheless, due to the applied discount rate of 2.5% this higher level of consumption in the long-term in the B-scenarios is reduced significantly as Table 6 shows. The accumulated deviation of consumption from the Reference case along the B-scenarios is only positive for Scenario 3B. That means that the discounted payoff to cover the investment costs is only sufficient in the case where the EEMs are implemented in combination with a moderate expansion of RES support.

Change of employment

A crucial factor regarding the development of welfare is the amount of available labor force. As mentioned in above a 5%[45] level of unemployment was assumed in the reference case. This approach is based on the neoclassical approach that at an existing wage a certain amount of the labor force is not willing to supply their manpower.

Figure 24 shows the overall effect of the scenarios over the assessed 40 years period. In this figure positive effects on employment (i.e. decrease of unemployment rate) are displayed on the positive axis. I.e. the +1% line in the figure stays for a 1% decrease of the reference unemployment rate.

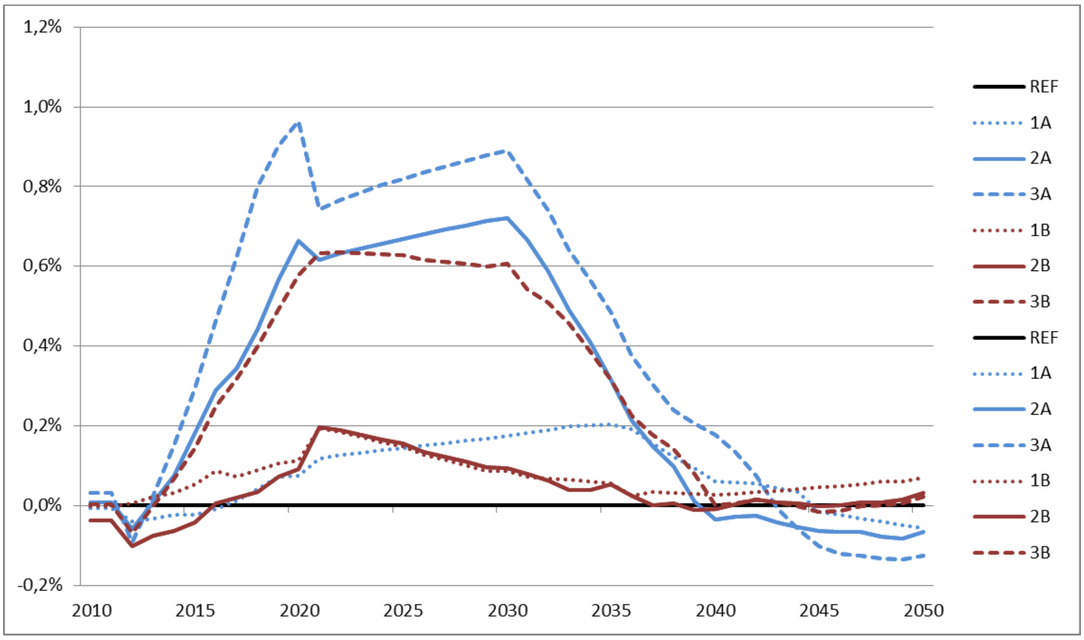

Figure 24: Absolute change of employment rate of Austria

In Figure 24 generally the A-scenarios tend to have positive effect on the labor market. The reason for the positive effect is that the RES-expansion of the A-Scenarios significantly includes biomass intensive technologies. These technologies demand domestically produced biomass products as input which triggers a further demand for labor.

It can be seen that focusing only on EEM (case 1B and 2B) has just a moderate positive impact on the employment whereas a combination with a moderate increase of RES-support in case 3B leads to highly positive effects on employment. This result is counterintuitive since the EEM largely consist of investments in construction activities and are thereby labor

[45] 5% is an approximation of Austria's average unemployment level in 2010 (4.4%) (Statistik Austria).

intensive. As it turns out the increase in the activity of the construction sector (CONT) due to the investments in EEM decreases the activity of another labor intensive sector which is “other services” (SERV). The economic sector SERV is a large part of the domestic consumption of the public and private consumer. This means that as soon as the private and public consumers invest in EEM (and reduce their other consumptions) the demand for SERV decreases and so does the demand for labor (as SERV is more labor intensive than CONT). However, as CONT is more labor intensive than the weighted average of all other economic sectors, the investments in EEM have a minor but noticeable positive impact on the employment.

To conclude, this chapter shows that – according to the underlying model – the expansion of RES capacities and the implementation of EEM have a noticeable effect on welfare and the economic activities in Austria. However, the results of chapter 4.1 merely display the macroeconomic view of the scenarios. Other factors like external effects as well as RES and greenhouse gas certificates trade have to be taken into consideration as discussed in the following chapters.

4.2 External effects of the assessed scenarios

When implementing measures to convert the energy supply system into a low carbon system the resulting impacts on society’s welfare are not only caused by the resulting effects on markets (e.g. labour or goods market). Rather, society’s welfare is also affected by effects not represented on markets and not fully accounted for by individuals. Literature often refers to this kind of effects as “externalities” or “external effects”, which can be positive or negative and usually are not considered sufficiently in economic assessments and decision making processes. The lack of taking into account externalities in decision making processes leads to an inefficient allocation of resources from an overall society’s welfare point of view and therefore to a society’s welfare loss.[46] Thus, to maximize the Austrian society’s welfare an Austrian strategy for increasing the share of renewables in the final energy consumption should take into account also externalities besides macroeconomic effects.

In the following we provide a short introduction on different kinds of externalities as well as their methods for quantification and constraints. In a subsequent step, energy related external effects from the six analysed scenarios are discussed in order to compare and analyse different scenarios as well as to show the impacts of different policy choices. Finally we test the role of the discount rate for the magnitude of external effects.

Many efforts have been made in the past to understand different types of external effects and to quantify them. Studies such as ExternE[47], CAFE[48], NewExt[49] or RECaBs[50] are only a few examples.[51] Corresponding literature distinguishes between the following types of external effects from energy use: [52]

[46] See Friedrich et al. (2004), p. I-1
[47] Externalities of Energy; Bickel & Friedrich (2005)
[48] “Clean Air for Europe”; Watkiss et al. (2005b)
[49] “New Elements for the Assessment of External Costs from Energy Technologies”; Friedrich et al. (2004)
[50] Renewable Energy – Costs and Benefits for Society; EA Energy Analyses (2007)
[51] For a comprehensive compendium see e.g. Maibach et al. (2007), p. 128 et seq
[52] For a comprehensive compendium see e.g. Steiner (2006) or EA Energy Analyses (2007)

- Damages from climate change caused by greenhouse gas emissions: the anticipated increase of extreme weather events (floods, draughts, etc.) may not only lead to damages on infrastructure and environment (e.g. crop yields), but also to impacts on human health, e.g. caused by extreme and long-lasting heat waves.
- Damages from air pollutants on human health, materials and crops: besides particulate matter (PM_{10}, $PM_{2.5}$) also SO_2, NO_x and VOC emissions affect human health through the formation of secondary pollutants. Furthermore, emissions of NO_x and VOC affect human health through the formation of ozone. Buildings-related damages are mainly caused by SO_2 (acidification), but also by ozone. Emissions from SO_2, NO_x and VOC also adversely affect crops and ecosystems through the formation of secondary pollutants.[53]
- Potential costs from nuclear damages based on historic records. Moreover, this component includes long-term health costs of radioactive emissions from abandoned uranium mill tailings.[54]
- Costs of fuel supply security (if not internalized)
- Noise
- Some other external effects like reduced biodiversity, damages on the overall appearance of the landscape or usage of exhausting energy sources[55]are also mentioned in literature.

However, though there is a wide variety of types of external effects caused by the use of energy, it can be concluded from literature that the lion's share of human health and environmental effects from energy use stem from air emissions. Air emissions typically account for 85 % or more of total external effects from energy use.[56] When adding also external effects from climate change it can be concluded, that the vast majority of external effects from energy use described in literature is represented in the subsequent analysis.

For determining external costs of greenhouse gases, quantifiable damages of global warming are estimated. However, in order to address large uncertainties and possible information gaps, an "avoidance cost" approach is used.[57] Damages from air pollution are estimated with the help of the "impact-pathway" approach.[58] Figure 25 shows in a simplified way the main steps of this approach:

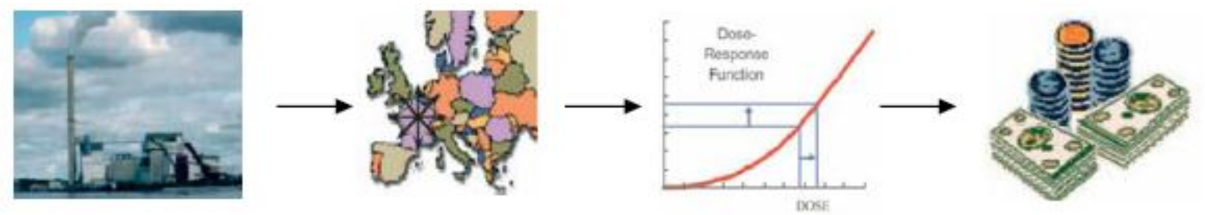

Figure 25: Principal steps of the impact-pathway approach for estimating external costs of air pollution (Source: Bickel & Friedrich et al., 2005)

[53] Compare with European Environment Agency (EN35)
[54] Compare EA Energy Agency (2007), p. 77
[55] See Kaltschmitt et al. (2000)
[56] Compare Burtraw & Toman, p. 2
[57] See Bickel & Friedrich (2005), p. 1
[58] See Bickel & Friedrich (2005), p. 1 and p. 35 et seq.

In a first step, relevant technologies and pollutants are specified, i.e. the quantity of emissions per energy output (for instance of a power plant) is surveyed. In a second step, the dispersion of pollutants is calculated. By applying a dose-response function in a third step the physical impacts of emissions on human health, materials and crops etc. are estimated. In a final step effects on human health, materials and crops etc. are monetized.
Although the main principle of this approach is widely used in literature, detailed assumptions vary considerably. Taking the modelling of air pollutants' dispersion as an example: whereas the CAFE study uses the EMEP model, ExternE calculates the dispersion of air pollutants via the Windrose Trajectory Model.[59] Furthermore, literature has varying assumptions about the harmfulness of air pollutants.[60] Also the monetization of damages (mainly on human health) is rather contentious as there are different methods: Whereas ExternE uses the "Value of Life Years" (VOLY) approach, CAFE takes the "Value for a Statistical Life" (VSL) approach which leads to higher estimates.[61]
Furthermore, environmental externalities are highly site-specific and external costs per air pollutant "will vary widely even within a given country according to the geographic location"[62] CAFE states that generally "the highest damages are found from emissions in central Europe and the lowest from countries around the edges of Europe. This reflects the variation in exposure of people and crops to the pollutants of interest – emissions at the edges of Europe will affect fewer people than emission at the centre of Europe."[63]
These uncertainties, different quantification approaches and dependencies on geographical circumstances complicate the assessment of external costs from energy use. Nevertheless it is necessary to take external effects into consideration because otherwise this may result in making wrong decisions as stated by Bickel & Friedrich et al. (2005): "… the uncertainties should not purely be looked at by themselves; rather one should ask what effect the uncertainties have on the choice of policy options. The key question to be asked is *how large is the cost penalty if one makes the wrong choice because of errors or uncertainties in the cost or benefit estimates?* "[64] The authors came to the conclusion for numbers provided in ExternE that "the risk of cost penalties is surprisingly small even with a very large range of uncertainties." [65]

4.2.1 Methodology for calculating external effects

The methodology to quantify the changes of external effects in the six different scenarios of this project can be split into two components. The first component is the quantification of the change in emissions caused by the implementation of measures in the considered scenarios. In the second component these emission changes are multiplied by marginal damage costs of CO_2 and relevant local air pollutants. Certainly, among the great variety of sources for externalities (beside emissions also noise, biodiversity, etc.) it is clear that changes in emissions of greenhouse gases and local air pollutants account only for a part of total changing externalities. However, according to Aunan et al. (2000) health effects – mainly

[59] Watkiss et al. (2005a), p. 4
[60] See European Environment Agency (EN35), p. 10
[61] For a more comprehensive comparison of both approaches see European Environment Agency (EN35), p. 11
[62] European Environment Agency (EN35), p. 4
[63] Watkiss et al. (2005b), p. 12
[64] Bickel & Friedrich et al. (2005), p. 264
[65] Ibid

caused by emissions of local air pollutants – typically account for 70-90 % of the total value of externalities. Therefore, by including externalities caused by local air pollutants and a changing climate, the major part of externalities described in literature is considered in the analysis.

First component of the methodology:
Aim of this component is to quantify annual occurring domestic effects on greenhouse gas and local air pollutant emissions, which are caused by *fuel switch* and *energy efficiency measures* in the different scenarios analysed. This quantification is partly based on the results of the Green-X model, which derives for each scenario data on increased use of RES for transport as well as for generating electricity and heat. This expanded use of RES substitutes energy sources for generating electricity, heat and mobility in the previous – i.e. pre 2011 – composition of the energy mix (before additional measures were implemented). This is similar for energy efficiency measures, where avoided energy consumption is composed by a mix of not only fossil sources, but also renewable sources. Calculations of energy savings from energy efficiency measures are based on the study "Energy Transition" (WIFO 2011), that provided comprehensive data regarding energy efficiency measures in Austria.
Based on RES expansion as well as energy efficiency in different scenarios emission factors have been assigned to each energy source (technology). This enabled us to calculate the change in emissions compared to the reference scenario: a fuel switch from fossil based energy to RES leads to a lower need for fossil energy, which goes along with reduced emissions from greenhouse gases and in some cases local air pollutants. On the other hand an increased use of RES leads also to emissions of local air pollutants (e.g. due to combustion of biomass). The reduction in energy demand by energy efficiency measures in contrary reduces emissions and is not accompanied by emission increases from other energy sources. The used emission factors per unit of energy output of a specific technology are based on most current information, mainly on data from the GEMIS database (Global Emission Model for Integrated Systems)[66], but also in some cases from literature for specific technologies. Assigning emission factors to a changing use of energy sources leads to information about changing emissions of greenhouse gases and local air pollutants (NO_x, SO_2, NMVOC, NH_2, particulates, CO) for each scenario.
In general, the emission effects of interest in these calculations are those, which would be achieved over the service life of the measure (for expanding RES-capacities and energy efficiency). The measures considered in the analysis are those implemented by 2020, the year by which the agreed RES-targets must be achieved. However, effects of measures are considered up to 2050 as measures have service lifetimes beyond 2020. That means that external effects of measures were considered from the time of their implementation until the end of their lifetime– also beyond 2020 but no longer than 2050.
We decided to set the system boundary in a way that only direct[67] emissions from energy use are considered, since a comprehensive life cycle analysis for each technology would go beyond the scope of this study. This approach is therefore certainly sufficient for contributing to the decision on which strategy (1A-3B) should be pursued for achieving Austria's RES

[66] Umweltbundesamt (2009b) (Austrian Environment Agency)

[67] Direct emissions are emissions which occur at the same time when running a technology (e.g. emissions in fine particulates due to the combustion of biomass for heating purposes). It does not include emissions occurred for manufacturing a technology or for producing fuels for running a technology

target. However, one should be aware that a direct comparison of RES technologies has certain limits as discussed in section 0 (under “external effects of technology options”) below.

Second component of the methodology:
Within the second component of the applied methodology calculated emission effects from RES-expansion and energy efficiency are monetized. The monetization of various emission types is conducted by valuating emissions with corresponding marginal damage costs (MDCs) of respective emission types.
As mentioned above, the calculation of MDCs is not straightforward. They depend on many conditions (geographic area, population density at emission sources, etc.) and are therefore not easy to quantify. These uncertainties in estimating MDCs are often expressed by offering ranges for MDCs for each gas and pollutant. However, this is at the expense of providing a clear and unambiguous picture about the external costs of air pollution and global warming. Moreover, providing only ranges of monetized external effects may impede clear statements about the strategy Austria should focus on. Therefore, instead of using a range of MDCs, MDCs per greenhouse gas and air pollutant where taken which adequately take into account the specific geographic area of Austria.

Table 7 presents the MDCs we used in this study. These figures can be seen as rather lower bounds in the corresponding literature.

Table 7: Applied marginal damage costs per tonne of air pollutant and CO_2

Gas / Pollutant	Marginal Damage Costs (€ / metric ton)	Source
Nox	8700	Maibach et al. (2007)
SO2	8300	Maibach et al. (2007)
NMVOC	1700	Maibach et al. (2007)
NH3	12000	Watkiss et al. (2005b)
Particulates	11600	Maibach et al. (2007)
CO	262	Lechner et al. (1998)
CO2	80	Watkiss et al. (2005c)

In a final step, external effects from annually changing emissions are discounted. The reason is that benefits as well as costs, which are generated/will occur in the future, are perceived to be less valuable in the present. A high discount rate leads to a high depreciation of future values. In the present analysis a discount rate of 2.5 % has been applied – the same magnitude of discount rate as applied in comparable studies (e.g. WIFO 2011). However, to show the impacts of changing discount rates on results, aggregated external effects are also exemplarily calculated with other discount rates.

4.2.2 External effects of different scenarios – overall comparison

In the following, external effects are shown for each scenario. Figure 26 shows for each scenario the sum of discounted annual external benefits and external costs from RES expansion and energy efficiency measures implemented within the time period 2011-2020. Certainly, external benefits and costs of the implemented measures go beyond this period, until the end of the expected service life of investments made. On the one side, the use of RES technologies causes external costs due to emissions of local air pollutants (e.g. biomass). In the analysed scenarios heating with renewable energies (RES-H) causes – in absolute terms – the highest external costs, whereby the highest share of external costs from heating is caused by non-grid heating. Comparatively low are external costs caused by electricity generation from renewables (RES-E) and transport using renewable fuels (RES-T). However, on the other side, reducing emissions from the reference energy mix by an intensified RES expansion in the sectors grid-heat (Avoided-Reference-H-grid) and non-grid heat (Avoided-Reference-H-non-grid) as well as electricity (Avoided-Reference-E) and transport (Avoided-Reference-T) leads to a compensation of external costs from using RES

Once again, an intensified use of RES in the sector heating achieves the highest external benefits, whereby especially transforming non-grid heating systems leads to the highest external benefits. It turned out (illustrated by Figure 26) that external benefits from RES expansion by far exceed external costs due to emissions of local air pollutants from RES use (e.g. form biomass). Beside RES expansion also energy efficiency measures leads to external benefits. In this respect one major advantage of energy efficiency measures is that they do not only lead to a substitution of energy sources but to a real reduction of energy demand. For the analysed scenarios, most external benefits can be achieved by energy efficient buildings (EFF-Buildings). However, also external benefits caused by energy efficiency in the production sector (EFF-Production) and transport service (EFF-T) are not negligible.

As shown in Figure 26 external benefits as well as external costs of RES expansion steadily rise from the reference scenario to scenario 3A. In the B-scenarios both external benefits as well as external costs of <u>RES expansion</u> are comparatively low, as the general demand for energy decreases and therefore less RES expansion is required. Nevertheless, in the B-scenarios external benefits are further increased by energy efficiency measures.

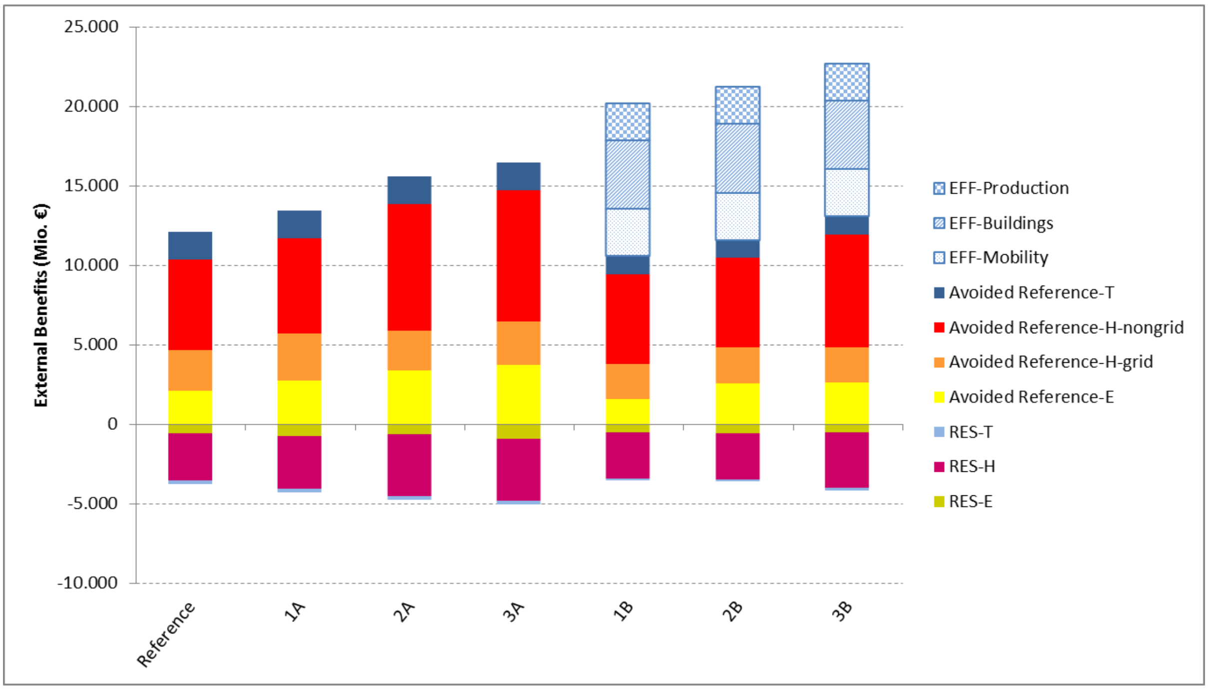

Figure 26: External Benefits and Costs of measures implemented between 2011 and 2020

To ensure the comparability of the scenarios, balancing external benefits with external costs is necessary. These net external effects of each scenario are shown in Figure 26. It can be seen that those scenarios, which include energy efficiency measures (B-scenarios) gain much more net external benefits than scenarios without energy efficiency. Moreover, net external benefits of the scenarios become much more significant when comparing different strategies leading to the same share of RES compared to the gross final energy consumption. For instance: a RES share of 34% could be achieved either by scenario 2A or 2B – or nearly already by scenario 1B. Comparing net external benefits of these scenarios reveal that achieving the target of 34% by including energy efficiency measures (1B or 2B) leads to a rise in external benefits of approximately € 6.7 billion (difference 2B-2A). This pattern can be seen too, when scenarios resulting in a RES-share of 36% (3A, 3B) are compared: choosing scenario 3B leads to € 7 billion higher external benefits than achieving a 36% RES share with scenario 3A.

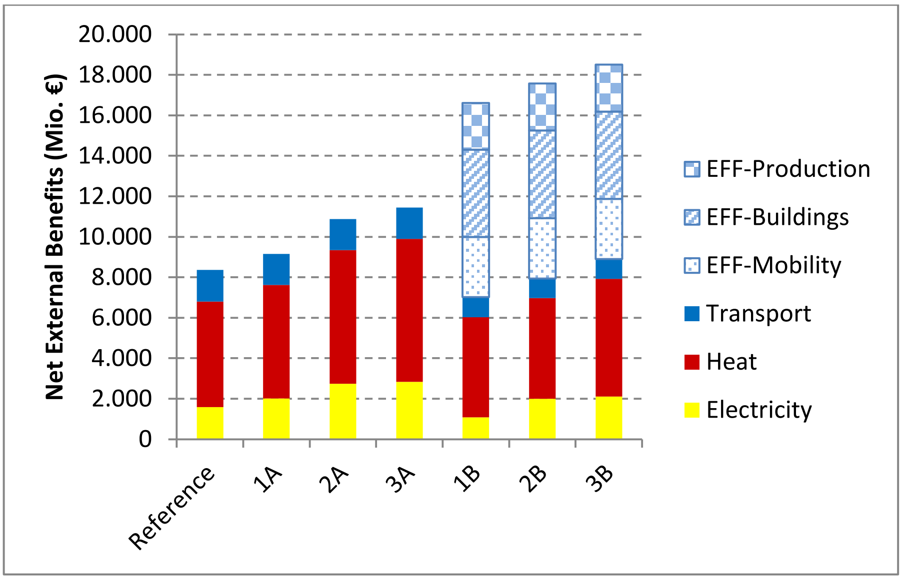

Figure 27: **Remaining external benefits after subtraction of external costs (net external benefits) of measures implemented between 2011 and 2020**

The advantage of including energy efficiency in the portfolio of measures becomes even more evident when we compare all scenarios with the reference scenario (Figure 28). To meet the 34 % RES-target, the gains in external benefits by scenario 2B are 3.7 times higher than achieving this target by scenario 2A. Also, for meeting the 36 % RES-target, the respective gains in scenario 3B are more than threefold compared to gains from scenario 3A.

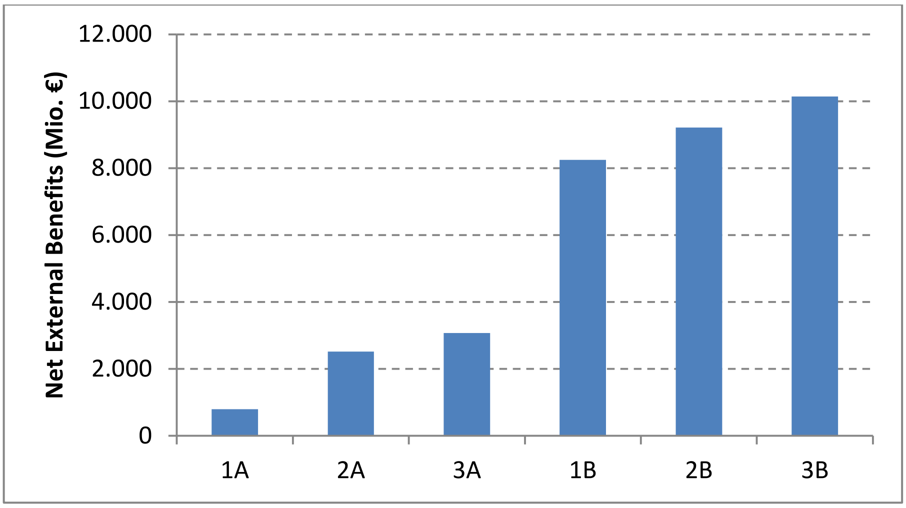

Figure 28: **External benefits after subtraction of external costs (net external benefits) of measures implemented between 2011 and 2020 in comparison to the Reference scenario (discount rate 2.5 %)**

4.2.3 External effects of sectors and technology options

Impacts of certain technology groups

The section above has provided information about the sum of external benefits and external costs from RES-expansion and energy efficiency measures. This section now provides information in a more disaggregated manner, firstly, for analysing the magnitudes of effects per measure group, and secondly, for showing the distribution of external benefits and costs over time. Figure 29 shows exemplarily annual amounts of external benefits and costs for scenario 3B. External effects are illustrated for analysed measure groups until the end of their expected service life, whereas 2050 was taken as a general limit for considering effects as their magnitudes become highly marginal at this time.

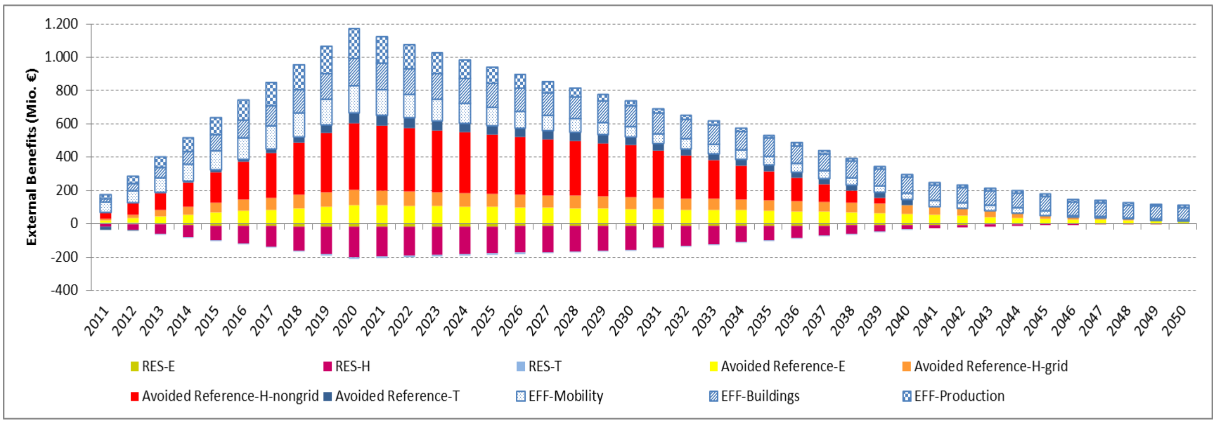

Figure 29: **External benefits and costs of measures implemented between 2011 and 2020 in scenario 3B**

It can be observed from Figure 29 that external benefits (positive external effects) from investments in RES-expansion and energy efficiency steadily rise as the capital stock for RES and energy efficiency is extended – in this analysis until 2020. On the contrary, also external costs from RES expansion rise steadily, but to a lower extent.

Even if efforts are made for the purpose to achieve (among other reasons) the target for renewable energy, it can clearly be observed that the bulk of external effects arise after 2020. Assuming a discount rate of 2.5%, net external benefits in the time period 2011-2020 are only one fourth to one third of total net external benefits of analysed scenarios. Thus it becomes evident that considering effects beyond 2020 is absolutely necessary for a comprehensive evaluation of the scenarios.

Taking the group of measures for RES-expansion together, most external benefits can be achieved in the non-grid heat sector by replacing old – and also fossil fired – heating systems ("avoided reference-H-non-grid") by new, non-grid heating systems using renewables. Certainly, some non-grid heating technologies (log wood, wood chips, etc.) based on renewables also cause external costs; however, they cannot overbalance external benefits in the non-grid heat sector. Compared to the non-grid heat sector, external net benefits of expanded RES-use in the grid-heat, electricity and transport sector are rather minor, whereas in sum they significantly contribute to the overall external net benefits of RES-expansion. However, the relatively low annual contribution from the grid-heat and electricity sector is partially balanced by their longer expected service life. These sectors lead to external benefits also beyond 2040, whereas most investments in non-grid heat made between 2011 and 2020 are expected to be already out of operation at that time.

The long service life is a special characteristic of many energy efficiency measures. Many energy efficiency measures implemented in 2020 have a lifetime of up to 2050 or even beyond (e.g. thermal insulation of buildings, spatial planning, etc.). Within potential energy efficiency measures in the production sector most external benefits can be achieved by intensifying industrial processes and reducing energy demand of industrial buildings. In the transport sector measures as improved spatial planning, increased use of public transport as well as stimulating non-motorized transport have a long lasting effect and are therefore in the long run most effective. In the building sector most external costs can be avoided by stimulating thermal restoration.

However, it is necessary to mention that also measures with lower potential to avoid external costs are necessary and advisable in order to maximize avoided external costs and to meet the country's environmental targets.

External effects of technology options

When expanding a country's RES-capacities the composition of RES-technology options should consider – among other criteria as macroeconomic optimization for instance – that external costs due to their possible emissions of technology options are minimized. At the same time external benefits from substituting fossil based technologies should be maximized.

For optimizing the portfolio of RES-expansion and substitution of fossil energy sources from the viewpoint of external effects, knowledge about the external effects of each technology option is necessary. However a direct comparison of RES- as well as fossil-based technology options is not straightforward as such a comparison is likely to be defective to a limited extent for three reasons: Firstly, specified external cost from single technology options are averages of different technology specifications among a certain technology option. External effects of single technology specifications might considerably deviate from the average as specific emissions per single technology specification will deviate.[68] Secondly, uncertainty exists about

[68] See for instance Bleyl-Androschin et al. (2011)

future developments of emission levels from single technologies. Certain technologies might better perform than expected in the future so that emissions and therefore estimated external costs might be overestimated. Finally, comparing technology options by comparing external effects from direct emissions provides a biased picture of technologies with no direct but indirect[69] effects. If indirect effects are not considered these technologies may have advantages in our approach, however they might – compared to technologies with direct emissions – actually perform badly in respect to types of external effects not considered in our analysis (e.g. potential impacts on biodiversity from hydropower; potential adverse effects on the overall appearance of the landscape from wind power; etc.). For that reason, specific technologies with only indirect emissions (but no direct emission) are excluded from the subsequent comparison of technologies. Taking the mentioned limits of comparing RES- and fossil-based technology options into consideration Figure 30 provides a comparison of technology options.

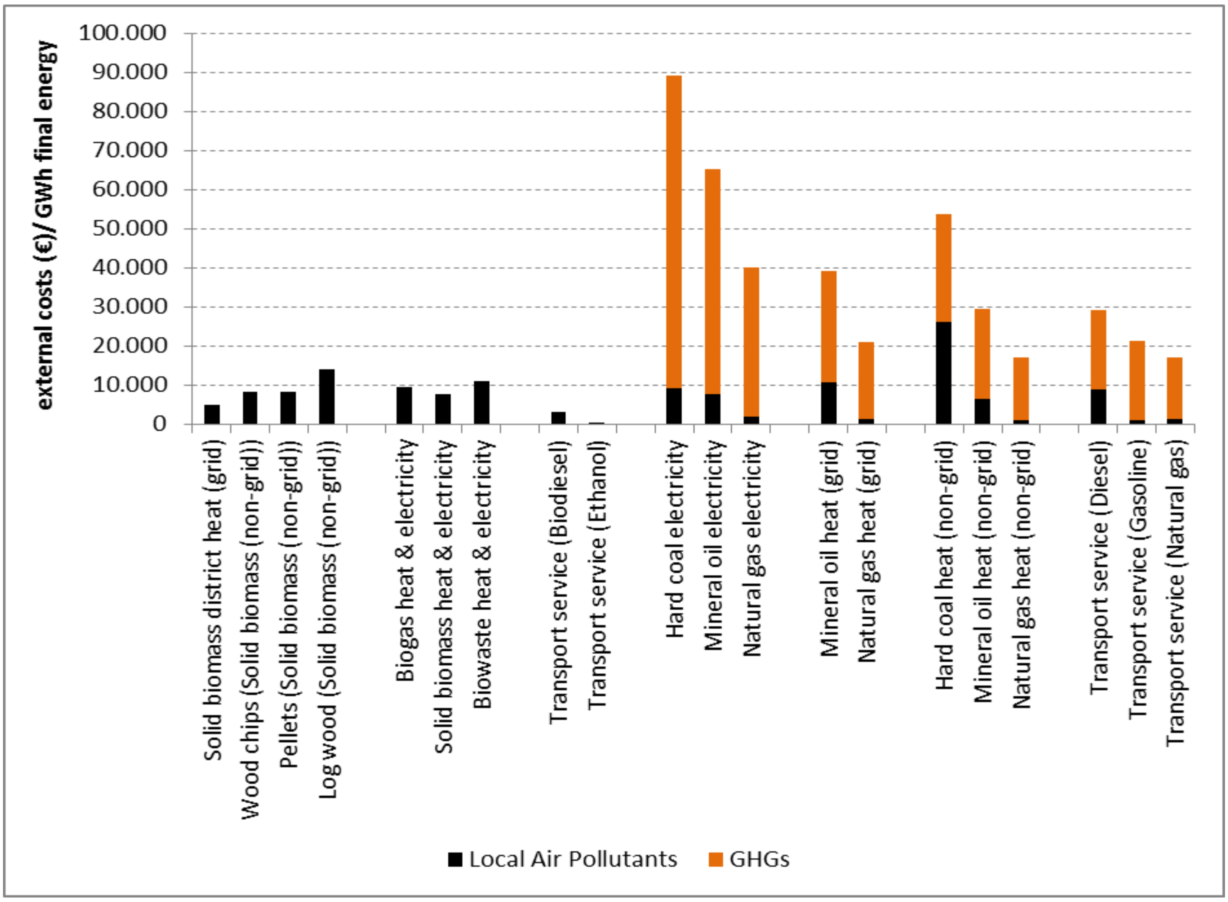

Figure 30: External costs of different technology options

It can be observed (illustrated in Figure 30) that for many technologies the bulk of external costs are due to emissions of CO_2. However, also the magnitude of local air pollutants is highly notable. The relatively high magnitude of external costs from CO_2 compared to external costs from local air pollutants depends on the one hand on the weight society puts on

69 Indirect emissions are emissions which do not correspond directly with running a technology. Indirect emissions arise either from manufacturing a technology (e.g. process emissions when manufacturing a PV-panel; emissions when constructing a hydro power plant; etc.) or from producing fuel for running a certain technology (e.g. generation of electricity for running heat pumps).

preventing climate change (mostly long-term damages) compared to the weight society puts on preventing damages caused by local air pollutants (mostly short- and medium-term damages). On the other hand, technologies have to fulfil certain emission standards, which (in most cases) avoid high emissions of local air pollutants from new technologies.[70]

Highest external benefits can be achieved by substituting fossil based electricity with renewable alternatives. Especially hard coal and mineral oil induce high external costs, especially caused by GHGs.

Also for heat production, hard coal and mineral oil are those fossil sources which cause the highest external costs per unit of energy output. Especially strongly polluting are small-scale non-grid heating systems based on hard coal, which cause highest external costs from local air pollutants both in relative as well as absolute terms (per unit of energy output). External costs from local air pollution for this technology are significantly higher than external costs for electricity generation by hard coal[71] (due to different emissions standards for air pollutants) However, using hard coal for non-grid heating purposes steadily decreased in Austria in the last decades.[72] Within the transport sector, substitution of diesel would lead to the highest external benefits.

Among all fossil energy sources, natural gas causes the lowest external costs especially due to its low emission of local air pollutants. However, in absolute terms natural gas based technologies are less favourable compared to all corresponding renewable energy technologies due to greenhouse gas emissions of natural gas.

For pure electricity generation with renewables only non-combusting technologies (hydro, wind, PV) are installed in Austria. Using biomass/ biogas/bio-waste for electricity generation leads also to the production of waste heat, which should be used in combined heat and power processes (CHP) to increase the gross efficiency. The analysis shows that external costs from combined heat and power generation by considered renewables are similar.

At producing purely heat with biomass, grid heat is more advantageous compared to non-grid alternatives based on biomass. At non-grid heating with biomass, wood chips and pellets cause lower external costs on average then log wood, which may vary considerably among single technology specifications (e.g. manual vs. automatic loading, etc.).

4.2.4 Influence of the discount rate

Considering annual flows of external benefits and costs beyond 2020 are necessary to achieve a comprehensive und unbiased data set for analysing scenarios. However, external effects evolving in the future are weighted less by the society than current effects. This lower valuation of future effects is expressed by the choice of the discount rate used to discount future effects.

The following figures (Figure 31, Figure 32, Figure 33) show the shapes of annual external benefits and costs from measures in scenario 3B with varying discount rates of 1.5%, 2.5% and 10% up to 2050. These figures illustrate the significant impact of discount rates on the magnitude of monetized external effects. The discount rate of 1.5% is similar to a discount rate

[70] E.g. standards according to the IPPC directive (2008/1/EG or 2010/75/EU)
[71] Especially caused by SO_2 und fine particulates
[72] Statistic Austria (2010)

proposed by *Nicholas Stern*[73] for valuating external effects. A slightly higher discount rate of 2.5% was used as default value as this discount rate was also used in other corresponding Austrian analyses (e.g. WIFO, 2011) and enables the comparability of results. A discount rate of 10% is fairly high – if not even far too high – to evaluate external – i.e. social – benefits and costs. However, this discount rate was chosen to assess whether this high rate is able to change the general conclusions regarding scenario choice.

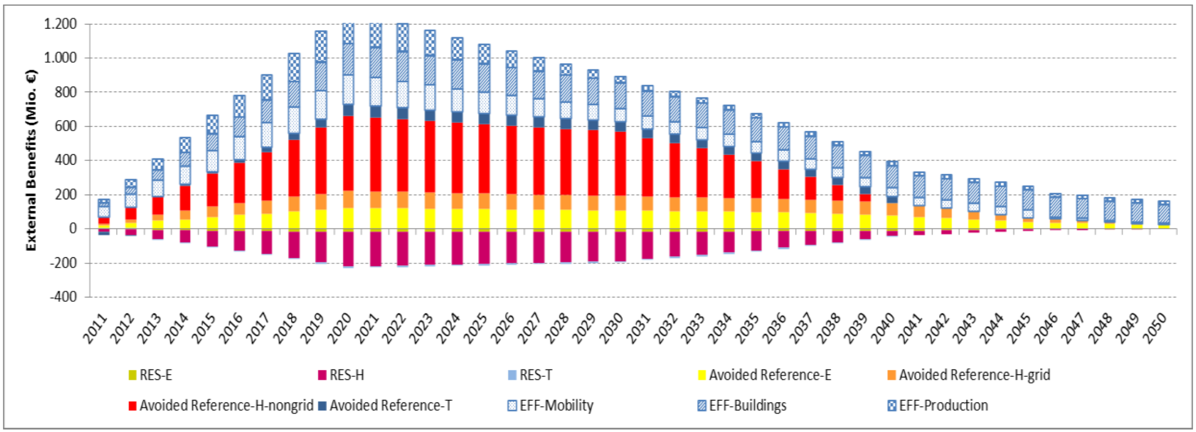

Figure 31: External benefits and costs of measures implemented between 2011 and 2020 in scenario 3B (discount rate 1.5 %)

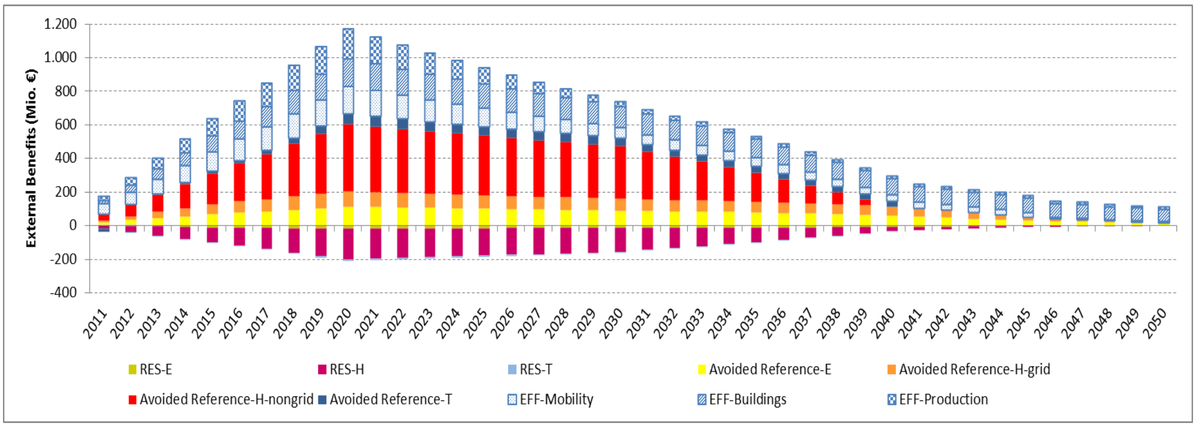

Figure 32: External benefits and costs of measures implemented between 2011 and 2020 in scenario 3B (discount rate 2.5 %)

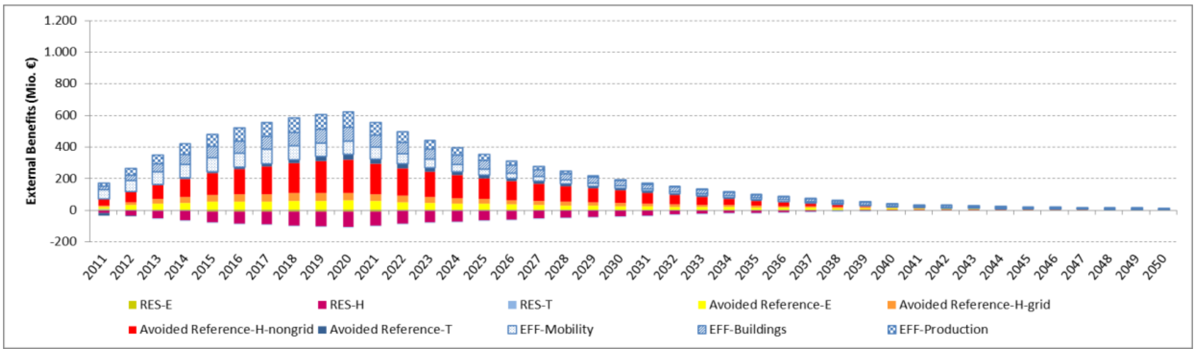

Figure 33: External benefits and costs of measures implemented between 2011 and 2020 in scenario 3B (discount rate 10 %)

[73] Stern (2007), Stern Review on the Economics of Climate Change

Irrespective of the choice of the discount rate, energy efficiency measures count for slightly more than half of overall net external benefits. However, in the far future the magnitude of external benefits from energy efficiency measures exceeds by far the one of RES-expansion. For instance, external benefits from energy efficiency beyond 2040 count for 3/4 of total net external benefits beyond 2040. A high discount rate therefore implies a disproportionately high discrimination/marginalisation of external benefits from energy efficiency measures. This in turn means that higher discount rates relatively worsen the advantages of the B-scenarios compared to the A-scenarios. However, as shown in Figure 34 the absolute advantage of scenarios, which include energy efficiency measures, is not eliminated even at high discount rates.[74]

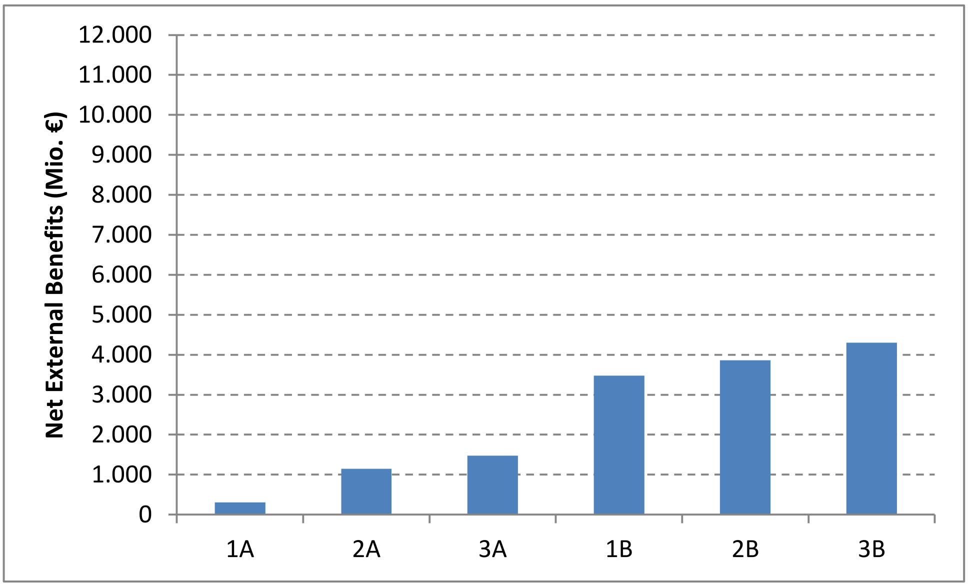

Figure 34: Remaining external benefits after subtraction of external costs (net external benefits) of measures implemented between 2011 and 2020 in comparison to the Reference scenario (discount rate 10 %)

We would like to point out, that increasing the discount rate for external effects – that are effects relevant for the society – tends to marginalize the contribution of external effects in the overall evaluation of scenarios – taking into consideration also macroeconomic effects or effects from RES and GHG certificates trade (see chapter 6). For illustration: whereas net external benefits of scenario 3B exceed those of scenario 3A by more than € 7.000 Mio. (both achieve a RES-share of 36%) when applying a discount rate of 2.5%, this advantage shrinks to less than € 3.000 Mio. when applying a discount rate of 10%.

4.2.5 Conclusions on impacts of external effects

The analysis has shown the substantial magnitude of external effects from RES-expansion and energy efficiency. Therefore, considering external effects is essential for an overall and comprehensive evaluation of different scenarios for increasing the RES-share in Austria.

[74] Compare Figure 34 with Figure 28

Although results depend on the choice of parameters such as the discount rate, the trends and conclusions stay robust. All analysed scenarios have significant advantages regarding external benefits compared to the reference scenario. However, scenarios, which include energy efficiency measures (B-scenarios) are more advantageous – from the external effects point of view – than scenarios without energy efficiency (A-scenarios). A rising discount rate tends to discriminate energy efficiency measures compared to RES-expansion. This leads to a relative disadvantage of B-scenarios compared to the A-scenarios. However, the absolute advantage of the B-scenarios compared to the A-scenarios remains even at the higher discount rates considered in this study. At higher discount rates, however, the importance of external effects becomes smaller compared to other evaluation criteria.

There are some measures within the entire measure portfolio, which provide – over a longer period – the highest amounts of external benefits (e.g. fuel switch in non-grid heat sector; thermal insulation of buildings). However, the contribution of other measures is also highly desirable as at any time external benefits of measures exceed potential external costs (e.g. local air pollutants at biomass combustion) going along with the measures. This leads to a maximization of external benefits.

Taking the argumentation above into consideration the most preferred scenario – from the viewpoint of external effects – is a scenario that maximizes net external benefits. In our case this is – from the point of view of external effects – scenario 3B.

5 The cooperation mechanisms: design, impacts and barriers

5.1 Comparing the cooperation mechanisms

The following chapters present the general features of the cooperation mechanisms, their potential advantages and disadvantages, possible impacts, barriers and preconditions. Furthermore, a comparison with the flexible mechanisms of the Kyoto Protocol (Joint Implementation (JI); Clean Development Mechanism (CDM); and International Emissions Trading (IET)) is made[75], in particular with regards to market dynamics and implications on price building and sharing of cost advantages.

In the following the general characteristics and incentive structures of the cooperation mechanisms as well as their potential, preconditions, impacts, and possible barriers are discussed.

Statistical transfer between EU Member States

Explanation of the mechanism
Article 6 of the RES directive states that Member States may agree on and may make arrangements for the statistical transfer of a specified amount of energy from renewable energy sources from one Member State to another Member State. Transfers may occur over one or more years and need to be notified to the European Commission annually. Article 6 also states that the information sent to the Commission shall include the quantity and price of the energy involved. This information is to be published on a transparency platform established by the directive which "shall serve to increase transparency, and facilitate and promote cooperation between Member States".

Advantages and disadvantages
Of the four cooperation mechanisms, statistical transfer is likely to be the easiest to implement. Except for potential legal or administrative hurdles for setting up contracts and realizing transfers, no broad frameworks need to be established. Given this limited administrative effort and the ex-post nature of statistical transfers, the mechanism can be used relatively quickly. However, future RES supply and demand are difficult to predict which leads to a high uncertainty on the mechanism's actual potential. This uncertainty could be reduced through early agreements as further discussed below.
Under statistical transfer the national support schemes remain in principle untouched which is of high importance for many Member States and which was a major reason for the rejection of

[75] Through Joint Implementation (JI) any industrialized country or economy in transition (countries with binding emission targets under the Kyoto Protocol) can invest in emission reduction projects in any other industrialized country or economy in transition as an alternative to reducing emissions domestically. Through the Clean Development Mechanism (CDM), industrialized countries and economies in transition can meet their domestic emission reduction targets by purchasing greenhouse gas emission rights generated from projects in developing countries. The International Emissions Trading mechanism (IET) allows parties to the Kyoto Protocol to buy governmental emission permits (assigned amount units, AAUs) from other countries to help meet their domestic emission reduction targets.

a mandatory private sector based trade of guarantees of origin (GO) as it was expected to undermine national support schemes (compare e.g. Klessman, 2009, Resch et *al.,* 2009). From this perspective, statistical transfer can be seen as a means for flexible RE target achievement while preserving national investment priorities. From the sellers point of view it can thus serve as an ex-post upgrade of existing national support schemes.

Potential and preconditions

As stated above, the real potential for statistical transfers is difficult to predict. This potential will primarily depend on the availability of surplus renewables shares to be potentially sold and their price as compared to domestic investments. While Jansen *et al.* (2010) expect the EU at large to be short in renewables shares in 2020 with a resulting strong demand-side competition, the Member States forecast documents[76] and the National Renewable Energy Action Plans (NREAPs)[77] suggest that the EU may slightly exceed its 20% target by 0.3% and 0.7% respectively. According to these forecast documents, a surplus of around 5.5 Mtoe would face a deficit of around 2 Mtoe.

The forecast documents suggest that:

- Italy would have the largest deficit in absolute terms (1.2 Mtoe);
- A transferable surplus could be expected in Bulgaria, Estonia, Germany, Greece, Lithuania, Poland, Portugal, Slovakia, Spain and Sweden;
- Spain and Germany have the largest surpluses in absolute terms, with 2.7 Mtoe and 1.4 Mtoe respectively.

It is not fully traceable to us how and based on which assumptions the different forecast documents were created and to which extent they may be biased by, e.g., strategic market positioning.

In any case, whether or not statistical transfer will constitute an economically efficient instrument for RES-target achievement, in addition to the physical surplus and shortfall-balance this instrument depends on the *willingness* and (e.g. legal or institutional) *capability* of potential sellers to actually sell their surplus credits.

We consider a selling of renewables shares as a no-loose benefit (and thus the selling willingness to be likely) for a potential seller if

- its 2020 and interim target achievement are not threatened, and
- transfers do not go beyond 2020[78] in order not to threaten compliance or to cause increased compliance costs for potential post-2020 targets.

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[76] The Member States forecast documents provide information on the expected use of the RES directive cooperation mechanisms including import needs and export availability of renewable energy shares. The documents and a summary are available on the renewable energy transparency platform on http://ec.europa.eu/energy/renewables/transparency_platform/transparency_platform_en.htm

[77] A summary of the NREAPs has been established by the Energy research Centre of the Netherlands (ECN) (http://www.ecn.nl/units/ps/themes/renewable-energy/projects/nreap/reports/). The 0.7 percent overachievement refers to an *additional energy efficiency scenario* while in the *reference scenario* the EU-27 target is not being met (less than 19% in 2020).

[78] The notification to the Commission shall refer to a timeframe not going beyond 2020 but this may not per se constrain the legal framework set up by the Member States.

Potential barriers and ways to address them

Potential barriers for selling and/or buying of RES-shares are legal and institutional barriers such as the creation of suitable governmental management bodies or accredited agencies. Countries may reduce these barriers by building on existing institutional structures and procedures such as developed for the International Emissions Trading under the Kyoto Protocol's article 17. In order to address the market uncertainty, early up-front contracts could be established in order to guarantee delivery and/or purchase of a certain amount of energy to be statistically transferred. However, the RES directive states that statistical transfer "shall not affect the achievement of the national target of the Member State making the transfer".

Conclusions on statistical transfers

Overall, countries interested in buying RES-shares are in a rather passive and dependent situation as compared to the other mechanisms under which also the buyer country is actively involved in expanding RES generation in the seller country. Therefore, it might be best for potential buyers to try to establish early agreements on future transfers in order to reduce supply uncertainty. Such early agreements may also be of interest for sellers if additional support shall be granted for domestic investments. The remaining risk of non-delivery will strongly depend on the national circumstances, in particular on how certain it is that a seller country actually exceeds its national renewable target.

Joint projects between Member States

Explanation of the mechanism

According to article 7 of the RES directive, under joint projects between Member States, two or more Member States (MS) may cooperate on all types of projects relating to the production of electricity, heating or cooling from renewable energy sources. Projects to be recognized under the directive have to become operational after 25 June 2009 and the period specified should not extend beyond 2020. In order for the investing MS to count the renewable energy produced by joint projects towards its target, the corresponding proportion or amount of renewable energy must be communicated to the Commission by the participating Member States, followed by a transfer from the host to the investor country's renewable energy statistic. For this transfer, a physical flow of energy between the cooperating MS is not required.

The directive explicitly states that the cooperation "may involve private operators". The possible role of private operators is however not further defined in the directive, which leaves quite some room for interpretation. It is obvious that private operators will be involved where physical investments are made. A major role of the private sector in addition to technical implementation certainly is its capability to identify economically viable renewable energy potentials. Private investors could initiate joint projects by requesting financial support from Member States where the domestic support system is not sufficient (Howes, 2010). However, the private-market involvement will not be comparable to Joint Implementation (JI) or the Clean Development Mechanisms (CDM) as the private sector will not be directly involved in statistical renewable energy transfers. As opposed to the Kyoto mechanisms JI and CDM, the generation of a margin through ownership and trade of "credits" by private firms is not possible under the RES directive mechanisms. Consequently, from a private investor's point of view, joint projects could be perceived as an extension of domestic support schemes.

Advantages and disadvantages

An advantage of joint projects, as compared to statistical transfer, is that they do not depend on an already existing renewable energy surplus of the host country. They require a more proactive role of the investor country and projects can be developed specifically for a forecasted shortfall of renewable energy shares. As compared to upfront-agreements under statistical transfer, the physical investment by the buyer country may to some extent reduce the risk of non-compliance due to an unexpected shortfall in the host country.

The possibility that private actors may request financial support for renewable energy projects through a joint project may help identifying specific renewable energy options under this mechanism. At the same time, joint projects allow for the joint realization of renewable energy projects in line with the interest of the involved governments regarding particular technologies or the inclusion of arrangements, e.g., on technology transfer.

Potential and preconditions

Joint projects include export opportunities for the investor country as well as socio-economic and environmental (co-) effects of additional investments in the host country, as well as co-costs such as potential efforts to integrate additional renewable energies into the distribution network. These factors have to be considered when the investor country weighs joint projects with a potential loss of positive domestic effects of domestic investments, such as job creation, domestic environmental benefits including emission reductions, energy autonomy and energy supply security. Joint projects do not necessarily involve the physical transfer of energy. However, energy purchase agreements might present in its own an incentive for the investor and/or host country to produce and trade additional renewable energy.

In their forecast documents some Member States identified particular technologies for joint projects in their countries. Joint projects regarding offshore wind are mentioned by Germany indicating a potential for two wind parks with 400 MW each; by Estonia stating the potential capacity being dependent on the integration of wind energy to the grid; and Ireland stating a “significant” potential for ocean and offshore wind while constraints and costs relating to grid infrastructure and interconnectors would have to be addressed. Hydropower is mentioned by Romania and Bulgaria including two potential hydroelectric plants on the Danube with 800 MW each and initial ideas on the exploration of the Black Sea’s potential. Latvia states biomass and wind as potential energy sources for joint projects without giving an indication of possible project sizes.

A major precondition for the implementation of joint projects is the agreement between the cooperating Member States on the investment made and the resulting share or amount of renewable energy (statistically) transferred. This appears to be more complex than for statistical transfer, where “only” a quantity and a price for the transfer of a, generally already existing energy production need to be defined. In principle, agreements on joint projects can be designed for one single project or a broader support framework (Klessmann, 2010). Depending on the specific implementation, broad frameworks could enable private firms to identify the most cost-efficient options. This may be most efficient if several technologies are covered within the frameworks of the scheme. However, the broader a framework is, the more it may interfere with existing national support schemes. Joint projects may evolve towards joint support schemes when the joint project framework in the host country is similar to the support scheme in the investor country (see e.g. Klessmann, 2010).

Another major aspect to be agreed on by the concerned MS is the timeframe for the transfer. Even though the notification to the Commission shall refer to a timeframe not going beyond 2020 this does not restrict the legal framework set up by the MS. An extension of the transfer beyond 2020 could increase compliance costs for post-2020 targets for the "host country" if it has to invest in more expensive technologies for its own compliance after 2020. Thus, host countries may want to limit the contract period to 2020. Where longer contract periods are desired (e.g. for the lifetime of an installation), the host country may agree only to "second-best" investments in terms of cost-efficiency under joint projects in order to keep a reserve of lowest-cost options for its own long-term compliance. Vice-versa, where transfer agreements end in 2020, new installations under joint projects may create benefits to the host country in terms of post-2020 target achievement.

Potential barriers and ways to address them

Barriers may include the legal framework for agreements between Member States. Public acceptability may play an important role in the investor country due to the co-benefits which are passed on to the host country (e.g. job creation, post-2020 target achievement, CO_2-reduction). This may be compensated for by, e.g., agreements on technology exports with the host country or the rules for sharing the renewable energy. Where more "co-costs" than benefits are expected due to the investment, public acceptability problems may arise also for the host country. For the host country it is of particular importance not to threaten future or even its own 2020-target achievements. In case of the Kyoto Mechanisms the threat that Joint Implementation project may make it more difficult for the host country to achieve its own Kyoto target was one of the reasons that several Member States did not accept to act as a host country under JI. France addressed this issue by discounting credits generated from JI projects in France in order to compensate the state for losing cheap domestic reduction opportunities (Steiner, 2011). Such a discounting could equally be applied to joint projects between Member States.

Conclusions on joint projects between Member States

Interest for joint projects has been stated by some Member States with several giving indications on potential project types and volumes. A high range of details need to be considered in agreements given the magnitude of possible transfer-costs and co-benefits such as grid expansion, technology export opportunities, and environmental and employment effects as well as implications of the transfer period (e.g. post 2020) of (statistical) energy transfers. Austria is most likely not in need for using the mechanisms for own 2020 compliance (see chapter 3) and might therefore act as host-party for joint projects. However potential negative post-2020 implications may arise in case of post-2020 RES transfer.

Joint projects between EU Member States and third countries

Explanation of the mechanism

Joint projects between Member States and third countries (Article 9 of the RES directive) are based on the same principle as joint projects within the EU. Differences include a limitation of the generated energy to electricity (under joint projects with other Member States heating and cooling are also included) and that the electricity to be counted towards the target compliance of a Member States has to be imported into the EU. The latter is necessary as otherwise the energy produced would not impact the physical energy mix of the EU. The RES directive defines further details in order to make sure that a physical import is actually achieved, in particular in regard to the interconnection capacity. At the same time, the involved Member States should "facilitate the domestic use by the third country concerned of part of the production of electricity by the installations covered by the joint project". A definition of "part of the production" is not given in the directive and it is not clear whether or to which extent this share is to be financed by the investing MS. The directive only states that "the amount of electricity produced and exported" must not receive "support from a support scheme of a third country other than investment aid granted to the installation". This leaves it open to which extent the consumption in the third country might offset benefits from cost-efficiency gains as compared to a joint project within the EU. Further, only newly constructed installations or newly increased capacities are eligible for transfer in order to "ensure that the proportion of energy from renewable sources in the third country's total energy consumption is not reduced due to the importation of energy from renewable sources into the Community". The operation of the new installation or the refurbishment has to start after 25 June 2005.

Advantages and disadvantages

The general characteristics of joint projects between EU Member States and third countries are comparable to joint projects between EU Member States. The potential advantage of joint projects between EU Member States and third countries is to make use of a more cost-efficient renewable energy generation from outside of the EU. However, additional hurdles will have to be addressed which may in many cases outweigh theoretical cost-advantages. This includes more difficult legal frameworks and investment environments, or infrastructural and grid issues. The obligation to physically import the electricity into the EU may be an important barrier as compared to EU-internal projects and could increase costs significantly.

Potential and preconditions

Four Member States (France, Greece, Italy, and Spain) note in their forecast documents that they may use cooperation mechanisms to develop renewable energy in third countries, either in the context of the Mediterranean Solar Plan[79] or in the West Balkan countries.

Potential barriers and ways to address them

Joint projects with third countries face some challenges, which do not apply to projects between Member States. The investment itself may be hampered by a (more) difficult investment environment in potential host countries and the fact that the produced electricity, which is to be counted towards the investor's renewables statistic, needs to be physically imported. This can be expected to increase transaction cost, which is why ECN (Jansen *et al.*, 2010) does "not anticipate that this instrument will be booming". In addition, this project type can be considered particularly politically sensitive due to an increasing demand for energy in host countries, to which new installations would only contribute to a limited extent. New installations being constructed primarily for electricity exports – possibly in areas with a lack of energy supply – may cause acceptance problems in host countries.

[79] The Mediterranean Solar Plan (MSP) aims to develop 20 GW of new renewable energy production capacities, and achieving significant energy savings around the Mediterranean by 2020. It is one of six key initiatives of the Union for the Mediterranean (UfM), launched in Paris on 13 July, 2008.

Conclusions on joint projects between EU Member States and third countries

Some potential for the use of joint projects between EU Member States and third countries has been identified in particular in the Mediterranean region and the Balkan which is reflected in the national forecast documents. However, this project type faces particular challenges such as the need to physically import electricity in the EU and potentially difficult investment environments, which may, at least up to 2020, significantly reduce the opportunity to actually contribute cost-efficiently to national target achievement.

Joint support schemes

Explanation of the mechanism

According to article 11 of the RES directive under joint support schemes, two or more Member States may join or partly coordinate their national support schemes. In such cases, a certain amount of energy from renewable sources produced in the territory of one participating Member State may count towards the national overall target of another participating Member State. This transfer may be done by statistical transfer of specified amounts of energy or by the setup of a distribution rule that allocates amounts of energy from renewable sources produced as a result of joint investment between the participating Member States. Where a distribution rule is chosen, each Member State shall issue an annual notification stating the total amount of energy, which is subject of the distribution rule.

Advantages and disadvantages

Joint support schemes can create incentives for the use of the most cost-efficient renewable energy potentials in a group of nations if a harmonized support is established across the participating Member States. However, the harmonization of support schemes across countries is complex. Given the different national contexts, factors beyond the mere support scheme (e.g. tax, grid access and others, see Klessmann, 2009) will have to be taken into account in order to reach overall comparable frameworks. This, in addition to the high administrative effort and potential legal and technical hurdles to reach transnational support frameworks renders the implementation of joint support schemes complex and lead probably to a lengthy process. Consequently, joint support schemes may be less flexible in the short-term as compared to the other cooperation mechanisms, which impedes a short-term, dynamic adaptation to the actual need for additional renewable energy generation in light of national targets. Additionally, the transnational nature of the mechanism generally complicates a fine-tuning to specific national needs. Also, in contrary to specific joint projects, (joint) support schemes create a framework under which the investor behavior, and thus physical investments, cannot fully be anticipated. This limits their predictability in terms of specific renewable energy volumes to be generated or targets to be achieved.

Joint support schemes are often discussed as representing a step towards a harmonized European framework, which is in the interest of the EU. A joint support scheme tailored to a specific group of nations may be a starting point and provide experiences for a larger, European-wide scheme. However, it remains to be seen to which extent such a joint support scheme would actually facilitate integration with support schemes of Member States not being part of a joint support scheme or being part of another joint support scheme.

Potential and preconditions

Given the high technical and legal complexity and the resulting long lead time for joint Support schemes, it can be expected that this mechanism will only be used to a limited extent for 2020 target achievement. However, a high potential is seen for some Nordic countries with e.g. Sweden and Norway establishing a joint quota system with tradable green certificates from 2012 onwards which could form the basis for establishing a joint support scheme (Greenstream, 2010)[80]. ECN recommends that the Dutch government enter this system with, at least, Sweden and identifies as the best option a mandatory minimum share of renewable energy to be imposed on suppliers in combination with a certificate system (Jansen *et al.*, 2010).

Comparable to joint projects, a fair distribution of the generated renewable energy, costs and benefits, including the allocation of additional support costs, needs to be found.

Potential barriers and ways to address them

Barriers include the difficulties in harmonizing several support schemes as pointed out above. While other cooperation mechanisms can be used relatively flexible and short-term, joint support schemes would ground on long-term strategic considerations. Given that Austria does not depend on the cooperation mechanisms in order to meet its target (see chapter 3), joint support schemes may not have sufficient benefits which would justify their potentially high transaction costs, in particular for the short timeframe till 2020.

Conclusions on joint support schemes

Due to its complexity, the establishment of joint support schemes can be expected to be too time- and resource-consuming for supporting short-term target achievement of countries with strongly differing energy policy frameworks. In the long run however, joint support schemes may be more efficient than joint projects once such a framework is established. Whether joint support schemes are suitable to support the EUs interest in a European-wide harmonization remains to be seen.

5.2 The potential use of cooperation mechanisms by Austria

Austria can be expected to reach or even exceed its 2020 renewable target with a moderate increase of RES support and/or additional energy efficiency measures (see chapter 3). From that perspective Austria does not depend on using the cooperation mechanisms. However, due to the potential for overachieving the 2020 target and particular interim targets, statistical transfer should be considered. Statistical transfer may offer a revenue stream from selling excess renewable shares without requiring additional investments. Because the future market for renewable shares is highly uncertain, this potential should be assessed early in discussions with potential trading partners, which may lead to early agreements. Investments in renewable energy and energy efficiency aiming an overachievement of the 2020 goal may thereby indirectly be co-financed through revenues from statistical transfer. An overachievement of RES targets can also help building a basis for potential post-2020 targets.

[80] The RES Directive explicitly highlights that some non-Member States – "third countries" – may also take part in the use of these mechanisms. These include the European Economic Area (EEA) countries of Norway and Iceland (The EEA Joint Committee decided in December 2011 to incorporate the Directive into the EEA Agreement).

Austria might allow renewable energy investments by other countries in the framework of joint projects. This may equally lead to improving the point of departure for post-2020 targets in case no post-2020 transfers of RES share take place. In particular, costs for achieving post-2020 targets may increase when the most cost-efficient renewable potentials are dedicated to joint projects that may include (statistical) transfers of renewable energy beyond 2020. This could be avoided through exclusion of the most cost-efficient renewable energy potentials from joint projects or through limitation of post-2020-transfers of renewable energy shares. Generally, the use of joint projects for investments in Austria would lead to substitution of domestic expenditures with foreign investments while maintaining a similar RES share (e.g. overachievement). At the same time macroeconomic benefits from foreign RES investments in Austria may be lower than those from pure domestic investment due to e.g. a potentially higher import of construction material and labor. The potential benefit of joint projects for Austria therefore is less obvious than the benefit from statistical transfer of existing surpluses. Whether Austria will have a net benefit from joint projects will consequently depend on the degree to which national co-benefits from RES investments are "priced in" in negotiations with investors. For Austria, which is on good track to reach its 2020 renewable target, joint support schemes may not have sufficient benefits which would justify their potentially high transaction costs, in particular for the short timeframe till 2020.

5.3 Comparison of cooperation mechanisms and Kyoto mechanisms

This section analyses major similarities and differences between the RES cooperation mechanisms and the flexible Kyoto mechanisms Joint Implementation (JI), Clean Development Mechanism (CDM), and International Emissions Trading (IET). Experience from the flexible Kyoto mechanisms may anticipate possible developments of the RES cooperation mechanisms. The purpose of the comparison is to identify factors that can lead to a successful use of RES cooperation mechanisms for achieving governmental targets and taking into account the sharing of cost advantages.

Through Joint Implementation (JI) any industrialized country or economy in transition (countries with binding emission targets under the Kyoto Protocol) can invest in emission reduction projects in any other industrialized country or economy in transition as an alternative to reducing emissions domestically. Through the Clean Development Mechanism (CDM), industrialized countries and economies in transition can meet their domestic emission reduction targets by purchasing greenhouse gas emission rights revealing from projects in developing countries. The International Emissions Trading mechanism (IET) allows countries with binding targets under the Kyoto Protocol to buy governmental emission permits (Assigned Amount Units, AAUs) from other countries to help meet their domestic emission reduction targets. IET is in most cases carried out under Green Investment Schemes (GIS) under which the revenues from the emission rights trade arte used to finance specific climate protection programs in the seller country.

Experiences made with the flexible Kyoto mechanisms Joint Implementation; Clean Development Mechanism; and International Emissions Trading provide some insights in the practical implications of particular mechanism features that also may apply to the RES cooperation mechanisms. Comparison of specific mechanism features, such as the mechanism type (transfer, project-based, support scheme), the way how cost-advantages are transferred or experienced hurdles in the implementation of the mechanisms can to some extent help anticipating future dynamics of the RES cooperation mechanisms. At the same time, none of the Kyoto and RES mechanisms are comparable over the entire range of factors that impact the success of a mechanism. Such factors include, but are not limited to supply and demand; legal and administrative hurdles; price building mechanisms; transfer costs and mechanisms that determine how cost-advantages are passed on; costs. Consequently, a one-by-one transfer of experiences made with any of the Kyoto flexible mechanisms to a RES cooperation mechanism is not possible.

Cost efficiency and price-building under the cooperation and Kyoto mechanisms

A prime function of the flexible Kyoto mechanisms and the RES cooperation mechanisms is the identification and exploitation of comparably cost-efficient investment opportunities for emissions and renewable energy target achievement respectively. The degree to which revealing cost-advantages are forwarded to the entity (governmental or private) in need of target achievement can however differ substantially. The Kyoto mechanisms Joint Implementation and Clean Development Mechanism under which generated credits are traded at a global market price were often criticized for the high margins they generate and from which the end-user does not benefit. The more the costs for generating these credits (implementation costs, transfer costs) are below the market price, the higher is the margin that e.g. project developers and implementers obtain.

JI and CDM credits (ERUs, CERs) are compatible with allowances under the European Emission Trading Scheme (EU-ETS) and can up to a certain amount be used by companies under the EU-ETS for compliance. The price of EU-ETS allowances (EUAs) serves as a benchmark for ERUs and CERs as the EU-ETS is the largest buyer of these credits.

The end-user of the credits will benefit from the difference between own target achievement costs (domestic in case of governments) and target achievement through purchase of credits. This is illustrated in Figure 35.

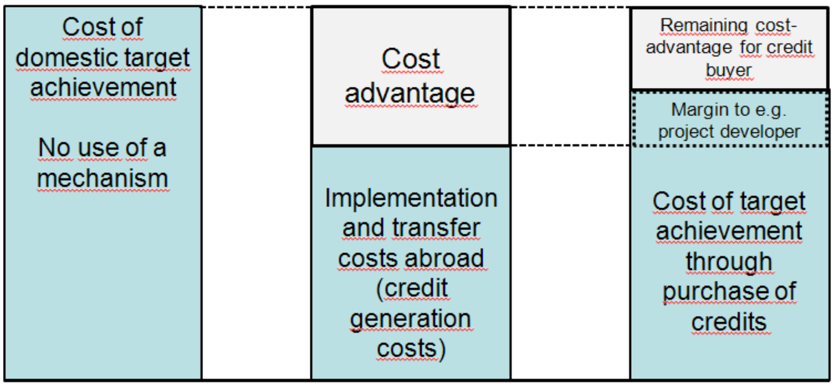

Figure 35: Cost advantage and its sharing between actors under a crediting system

Cost advantages in the case of national targets are here understood as the difference between costs of a domestic investment without use of a mechanism and the cheaper implementation and transfer costs under one of the mechanisms. This cost-advantage is not fully forwarded to the end-user but shared with e.g. project developers according to the market price of credits.

While JI and, in particular, the CDM are often criticized for the high margin that the private sector can generate, these margins create a strong incentive for the private sector to identify and exploit most cost-efficient project potentials which might not be achieved otherwise. The reason for the potentially high margins is the uniform market price for credits. Under JI and the CDM the margin primarily stays with the private sector. The private sector's importance for the Kyoto flexible mechanisms JI and CDM is linked to the fact that credits are generated, which can be owned and traded by private firms.
Under the RES cooperation mechanisms, ownership, trade and use of renewable "credits" by private firms are not foreseen. In order to identify and use the most cost-efficient renewable potentials, the RES cooperation mechanisms will thus much more rely on governmental initiatives. At the same time this can potentially allow for a higher cost advantage for governments. The share of the cost advantage that goes to the state will however strongly depend on the market dynamics, in particular on the way how prices (statistical transfer) or sharing of costs and benefits (joint projects, joint support schemes) are determined. For the determination of prices, two general approaches are thinkable:

1. bilateral negotiations, potentially with prices that are not made public (comparable to the trade of governmental emission rights – Assigned Amount Units, AAUs – under International Emissions Trading), and
2. an open market through, e.g., a trading platform (in particular for statistical transfer, comparable to JI/CDM) potentially leading to a more uniform market price.

Bilateral negotiations may lead to in-transparent prices as witnessed, e.g., in the case of International Emissions Trading allowing for a relatively large price range. The establishment of a trading platform for e.g. renewables shares for statistical transfer could lead to a more unified supply-demand based price development (see e.g. Klessmann *et al.*, 2010). A comparable effect may be achieved if bilaterally agreed prices are made public, e.g. on the transparency platform established by the RES directive. While this would lead to more transparency, a uniform price could in some cases be far above specific additional generation costs, leading to high margins for the sellers. Under the RES cooperation mechanisms the upper price limit may be derived from the costs for new installations or capacity increase in the investing or buying country or even from non-compliance cost (fines). Further, the price building may consider costs and benefits beyond the direct RES implementation and generation costs. This may include co-benefits and -costs and their sharing among project partners, such as energy supply security, environmental benefits (e.g. fine particulates reduction), job creation, or CO_2 emission reductions which will enter the national emissions Greenhouse Gas accounting in a post-2012 framework. The support system encouraging investment by the private sector in some of the RES cooperation mechanisms also impacts the extent to which the cost advantage is passed on to a government. Excessive support may occur, e.g., through feed-in tariffs that are above the additional marginal costs for renewable energy generation, or through investment support above the level that renders investments economically viable. Such cases show some similarity to the margin under a crediting mechanism discussed above. Due to the high number of factors impacting costs under the different mechanisms we do not aim anticipating overall comparative cost-efficiency of the different mechanisms. Instead, the subsequent chapter provides a general classification of the different flexible Kyoto mechanisms and the RES cooperation mechanisms by mechanism type and characteristics such as the potential sharing of the cost advantage.

Overview and classification of RES directive and Kyoto mechanisms

This section provides a general overview and classification of the RES cooperation and Kyoto flexible mechanisms characteristics. Table 8 below provides an overview of these mechanisms along the characteristics Mechanism type and Governmental cost advantages.

The mechanism type refers to the question whether the mechanism involves implementation of projects (e.g. construction of a renewable power plant) or support schemes or whether it is limited to transfer of existing surpluses of credits or renewable energy shares. The mechanisms type has direct implications for the cost efficiency and price-building discussed above. Where only transfers of existing renewable energy surpluses or project-based crediting occur, potentially high investment margins due to uniform market prices may go to the seller. Under support schemes, the support-efficiency plays a crucial role for the cost-efficiency of the mechanism. These cost-considerations are shown in the row “Governmental cost advantages” which refers to the question of whether a governmental buyer or a government investing abroad can potentially benefit from the major share of the cost advantage as discussed in the previous chapter.

The government/state is chosen here as the end-user because under the RES directive only the government is responsible for compliance with renewable energy targets. However, the same considerations would apply to private end-users (i.e. private credit buyers under the Kyoto flexible mechanisms).

Background Information:

Green Investment Schemes

Green Investment Schemes define the use of revenues from International Emissions Trading (IET) for climate protection investments. Within IET, governmental emission allowances (Assigned Amount Units, AAUs) are traded to assist the buyer country in its emissions target achievement. Because the major amount of surplus AAUs comes from the breakdown of the economy in Central and Eastern Europe in beginning of the 1990s rather than from targeted emission reductions, claims came up to bind revenues from sale of these units to climate protection investments in the selling countries. Because Green Investment Schemes are not, as opposed to IET, backed by clear international standards, bilateral agreements are needed to define revenue spendings. Such agreements include the type and scale of investment, the way how the budget is administered and allocated and how monitoring and verification is carried out. The AAU buyer may be involved to a certain extent in, e.g., selection of project types and monitoring activities. The bilateral agreements are highly heterogeneous in environmental stringency.

Table 8: Simplified overview of RES and Kyoto mechanism characteristics

	RES cooperation mechanisms			Kyoto flexible mechanisms			
	statistical transfer	**joint projects (EU or third party)**	**joint support schemes**	**Joint Implemen-tation (JI)**	**Clean Development mechanism (CDM)**	**International Emissions Trading (IET)**	**IET with Green Investment Scheme (GIS)**
Mechanism type	Transfer only (statistical renewable energy)	Project-based, potential transition towards support scheme (renewable energy)	Common support scheme (renewable energy)	Project-based (emission reduction)	Project-based (emission reduction)	Transfer only (emission allowances)	GIS: Project-based/host-country support via IET: Transfer of emission allowances
Main actors	Governments	Governments	Governments	Private sector	Private sector	Governments	Governments
Governmental cost advantages	Potentially high, depends on price building	Potentially high, depending on support system efficiency and cost sharing	Depends on support system efficiency	May be limited due to private sector margins	May be limited due to private sector margins	Potentially high, depends on price building	Potentially high, depends on price building

Table 8 above shows that a range of similarities exists between the flexible Kyoto mechanisms and the RES cooperation mechanisms. At the same time, only statistical transfer and International Emissions Trading are similar along all characteristics in Table 8, however statistical transfer may be easier to implement as for IET the host country has to meet eligibility criteria set by the UN including a registry for the transfer of credits.

IET is mostly carried out under implementation of Green Investment Schemes (GIS) under which revenues are bound to climate protection measures in the seller country. This adds to IET a project component which is to some extent comparable to joint projects under the RES directive and Joint Implementation (for GIS see box above "Background Information: Green Investment Schemes"). As opposed to joint projects and JI, under GIS the credit transfer occurs before the actual investments in projects. While this renders the implementation success a challenge, requiring both seller and buyer to actively follow up the transaction, joint projects, equal to Joint Implementation, require a physical investment before transfers can occur. This guarantees the implementation of the project. Joint support schemes have no equivalent among the flexible Kyoto mechanisms in terms of the mechanism type.

Experiences from Joint Implementation and Green Investment Schemes

In this chapter Joint Implementation projects and Green Investment Schemes are compared as they are implemented in the same countries, mainly central and eastern European countries.

Experiences from Joint Implementation and Green Investment Schemes have shown that the extent to which a nation makes use of a mechanism depends not only on the interest in the mechanism but also on a number of constraints in terms of e.g. physical project potential, administrative capacities, reputation and others. When comparing the number and of projects and amount of credits transferred regarding JI projects and IET/GIS-deals carried out by a country it is obvious that a nation that is successful in using JI is not necessarily successful in IET/GIS and vice-versa. Ukraine for example has a very high number of registered JI projects (see Table 9 below). However, even though it is one of the countries that sold one of the highest total volumes of governmental emission rights (AAUs) under IET/GIS, the number of deals is rather limited and selling has ceased while other countries kept on selling AAUs (Tuerk *et al*., 2010). Russia, holding the largest AAU surplus, did so far not participate in IET and has only recently started registering JI projects. Bulgaria and Romania have a number of registered JI projects. While Romania war not able to sell AAUs due to e.g. administrative hurdles at the government level, Bulgaria is starting only now to sell AAUs, several years after the first deals were planned. Latvia participated in the IET but does not have any registered JI project. Within the flexible mechanism of the Kyoto Protocol most buyer countries purchased credits form different mechanisms and different countries. One of the reasons to select a high diversity high diversity of seller countries was to hedge against delivery risk in the case of JI and CDM or the risks related to the implementation of appropriate GIS schemes.

The table below gives an overview of the participation of different countries in IET and JI.

Table 9: AAU deals under International Emissions Trading

Seller	Volume ($MtCO_2$)	Number of deals
Estonia	60,75	17
Czech Republic	102,6	13
Latvia	17,0	6
Poland	25,9	6
Hungary	13,6	4
Ukraine	47,0	3
Slovakia	15,35	3
Lithuania	30	1
New Zealand	0,05	1
Bulgaria	6	1
Total	318,25	55

Source: JI-pipeline October 2012 (http://cdmpipeline.org)

Table 10: Number of registered JI projects

Seller	Number of deals	Seller	Number of deals
Russia	199	Hungary	13
Ukraine	198	New Zealand	8
Czech Republic	59	Finland	3
Bulgaria	40	Spain	3
Poland	26	Slovakia	2
Lithuania	20	Belgium	2
Romania	19	Sweden	2
France	17	Latvia	1
Estonia	16		
Germany	13		
Total JI projects: 641			

Source: JI-pipeline October 2012 (http://cdmpipeline.org)

The numbers and specific cases described above do not clearly confirm past assumptions that IET/Green Investment Schemes would be more successful than JI due to the lower need to deal with the complex UN procedures (compare e.g. Klessmann, C. *et al.,* 2010, Ürge-Vorsatz *et al.*, 2007). Country-specific potentials under GIS proved to be misleading: While a very high AAU surplus did not mean that AAUs would actually be sold, countries implementing GIS partly had problems spending the AAU revenues due to limited project potentials or difficulties to agree on project types with buyers (Tuerk *et al*., 2010). Past experiences thus show that predictions based on supply-demand analysis were valid only to a limited extent. Similarly, for the RES cooperation mechanisms anticipated supply-demand balances may provide an indicator of future market dynamics but practical hurdles may dominate these in specific cases.

Because of the high diversity of factors influencing the successful use of the Kyoto mechanisms and the different nature of the RES cooperation mechanisms it is not possible to directly transfer past experiences with the Kyoto mechanisms to the capability of nations to make use of the cooperation mechanisms. For instance legal issues relating to transfer of Kyoto units may not be comparable to renewable energy transfers. Some similarities may occur where administrative structures did not enable to handle the implementation of a Green Investment Scheme. This may indicate potential difficulties in particular with the more complex RES cooperation mechanisms such as joint support schemes.

6 Integrated Assessment of the Scenarios

For the six key scenarios of this project an integrated assessment was carried out that included investment and operating costs, macroeconomic effects, external effects as well as costs/revenues from RES- and CO_2-trade. The assessment focused primarily on the time horizon 2050, thereby considering the long-term effects of the investments made up to 2020. A discount rate of 2.5% was used as default value; however, discount rates were varied to analyze the sensitivity of the results to the discount rate. Beside effects until 2050, also short-term effects until 2020 were considered. The quantitative comparisons were complemented by a qualitative analysis of the potential role that the RES cooperation mechanisms may play for Austria. The integrated assessment was carried out in several steps. In the first step (section 6.1) welfare effects – both originating from economic and environmental effects – were analysed. In a second step (section 6.2) effects on the activity balance (here defined as the sum of trade balance, CO_2- and RES-trade) were analysed. In a third step (section 6.3) required amounts for public as well as total expenditures were compared. In a fourth step (section 6.4) results from the prior steps were integrated to draw preliminary conclusions based on quantitative information. In a final step the assessment of quantitative data was complemented with the analysis on the potential role of RES cooperation mechanisms in the different scenarios.

6.1 Comparison of the welfare effects up to 2050

In this section the six scenarios are compared regarding their welfare effects that are composed by the consumption opportunities of the society and the sum of external costs and benefits. All numbers are relative to the reference scenario in which no additional policies are implemented.

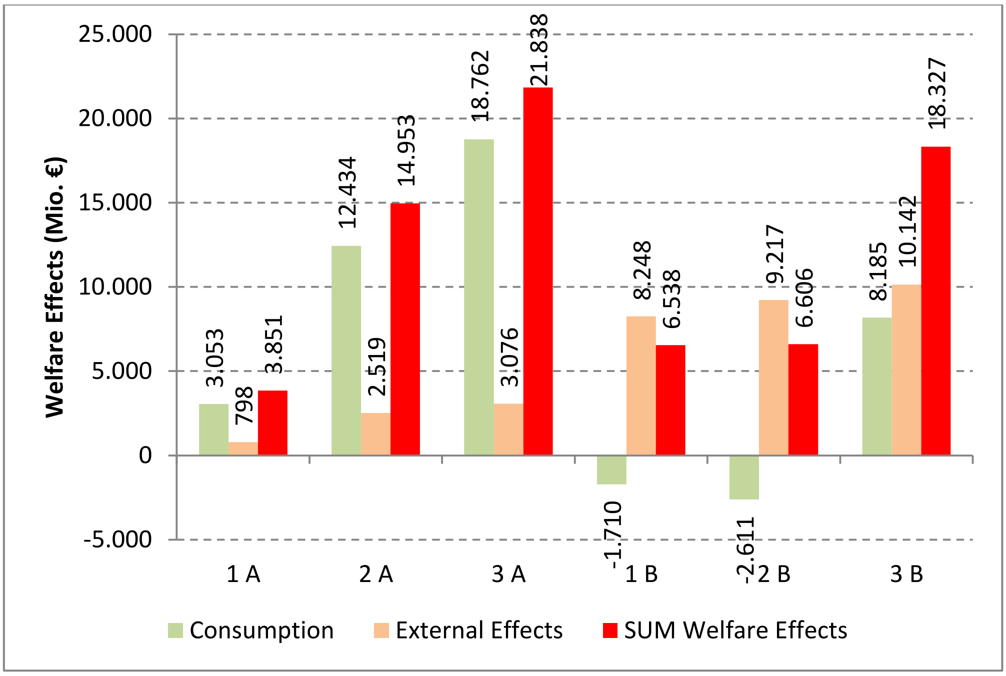

Figure 36: Welfare effects both from consumption and external effects compared to the reference scenario (discount rate 2.5 %, period 2011-2050)

Figure 36 shows the consumption opportunities of the society and external effects as indicators for welfare as well as the sum of both (relative to the reference scenario). Consumption does not only include the consumption of goods and services, but also the value of saved energy due to previous investments in energy efficiency measures (see chapter 4). The consumption in most cases increases compared to the reference scenario within the A and B scenarios in line with increasing RES shares (i.e. from 1A to 3A and from 1B to 3B), in particular within the A-Scenarios. On the one hand the use of non-competitive RES-technologies leads to negative consumption; on the other hand RES-expansion leads to higher returns from a larger capital stock, as well as a reduction of fossil fuel imports. The consumption in the B-Scenarios benefits from high returns (energy savings) of energy efficiency measures. At the same time the need for high initial investments (see chapter 4) in the B-scenarios decreases consumption. Due to this high initial investments needed within all B-scenarios, the net consumption effects compared to the reference scenario is positive only in 3 B (for details see Table 6).

For the second component of total welfare effects – external effects, in particular health effects of air pollutants – there is a net increase in external benefits in all scenarios compared to the reference scenario. This is the case in particular for the B-scenarios due to additional energy efficiency measures. While an increase of the RES-capacity reduces demand for fossil fuels but can still lead to additional emissions of local air pollutants, energy efficiency measures reduce energy demand in general and therefore always lead to a reduction of local air pollutants (for details see chapter 4). All results regarding welfare highly depend on the discount rate, which reflects the societal preferences towards short- or longer-term benefits or costs. Compared to Figure 36 discount rates were exemplarily varied to show the impacts on welfare (see Figure 37). The discount rate for macroeconomic effects (consumption) was increased exemplarily to 4 % (from 2.5 %) in order to have a similar magnitude as discount rates of investors. The discount rate for external effects was reduced to 1.5 % to be in line with the discount rate for discounting social costs as proposed, e.g. by Stern, 2007.

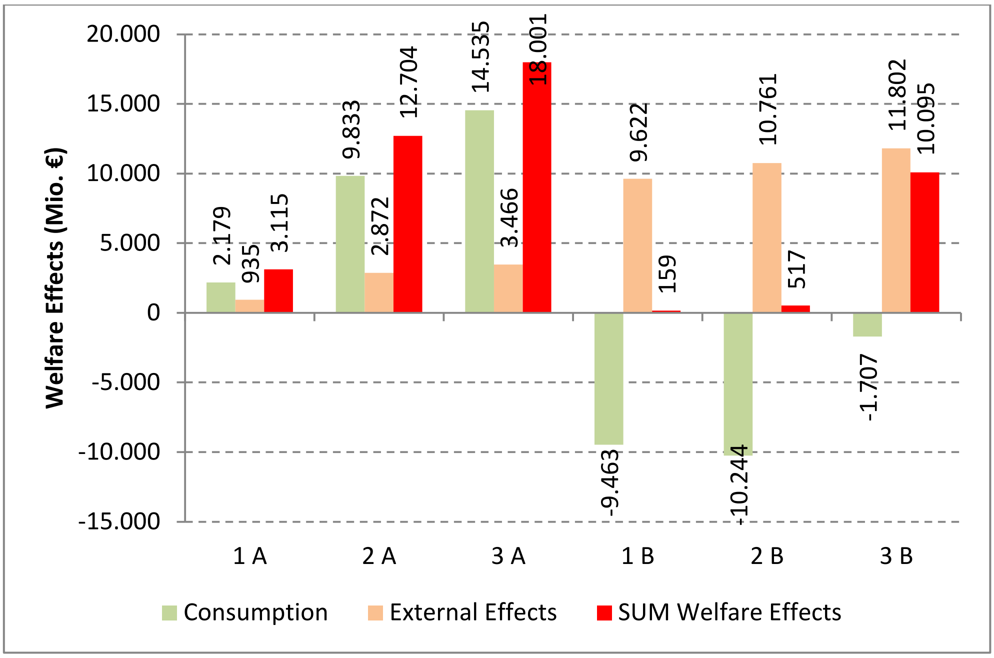

Figure 37: Welfare effects both from consumption and external effects compared to the reference scenario (discount rate 4 % for consumption, 1.5% for external effects, period 2011-2050)

At a discount rate of 4% for consumption the future consumption opportunities are valuated less than at a discount rate of 2.5% (default value). This leads to a disadvantage for the B-Scenarios compared to the A-Scenarios as the consumption is negative in the B-Scenarios in the short term and becomes positive only in the long-term. Regarding the external effects, the lower discount rate of 1.5 % leads to an increase of net external benefits in all scenarios, however over proportionally for the B-Scenarios. In sum, the higher net external benefits cannot compensate enough the disadvantages by the significantly reduced consumption for the B-scenarios to achieve the same welfare effects when discounting both macroeconomic as well as external effects with 2.5 %. However, the welfare effects still stay positive and show the same pattern even at this deviation in the discount rates.

To sum it up: All scenarios have a higher welfare than the reference scenario, with the A-scenarios having higher welfare effects than the respective B-scenarios. A particularly high welfare increase can be achieved when moving from a scenario without additional RES support (only reducing non-financial barriers and increasing the current RES support caps) to a scenario with a moderate RES support (compared to current RES support). This is the case when moving from 1A to 2A and from 2B to 3B. Also the step from moderate to strong RES support increase (compared to current support), from 2A to 3A is accompanied by a high welfare increase. Changing the discount rates and therefore the preferences towards short or longer benefits or costs can significantly change the preference for A or B scenarios.

6.2 Comparison of the activity balance up to 2050

Besides the welfare effects, the change in the activity balance is a second decision criterion for identifying the most beneficial scenario for achieving Austria's RES target. The activity balance as defined in this analysis includes the trade balance effects (up to 2050), CO_2 trade, and RES trade and is an indicator of whether and to what extent positive welfare effects are “borrowed” from abroad. As the market for RES shares is difficult to predict, two market assumptions regarding the trading period were made: RES trading taking place either from 2011 to 2020 or from 2015 to 2020. While the first trading period assumed an immediate start of RES trading, the other trading period takes into account that it may take a couple of years until a functioning RES market is established.

Figure 38 shows the strongly negative trade balance effects in the A-Scenarios as compared to the reference scenario. This is mainly caused by higher imports of goods when increasing the domestic renewable energy generation. This effect is particularly high when moving from scenario 2A to 3A, as this step requires a strong expansion of photovoltaic (PV) as an expanded use of photovoltaic leads in tendency to an increase in electricity prices, the competiveness of the economy and therefore its trade balance worsens. In addition, the worsening of the trade balance is caused by the need to import many photovoltaic components. Energy efficiency measures in contrary do not cause higher imports, and therefore the trade balance effects become negative only in 3B with (and caused by) a moderate increase of RES support.

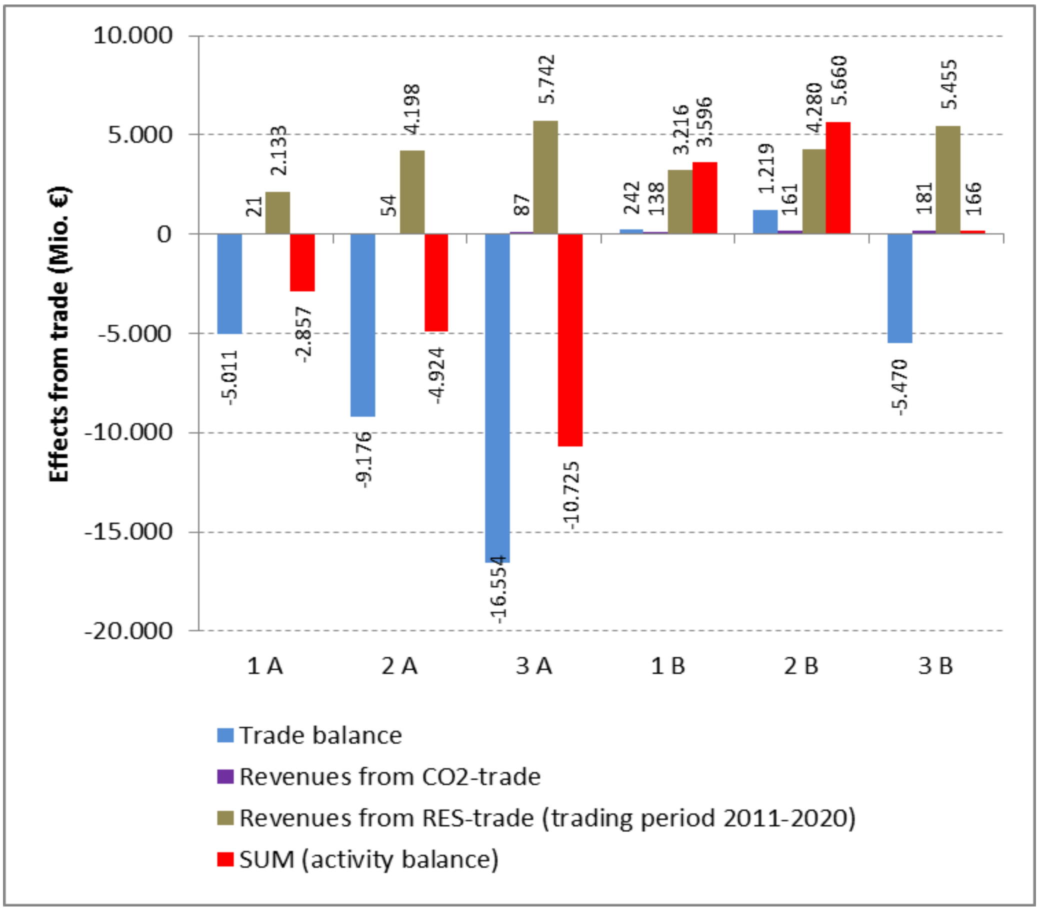

Figure 38: **Effects from trade compared to the reference scenario (RES-trading period 2011-2020)**

Negative trade balance effects are partly balanced by revenues from CO_2- and RES-trade. Figure 38 shows that revenues from CO_2-trade do not impact the overall effects on the activity balance to an important extent, whereas revenues from RES-trade have the potential to convert negative trade balance effects into positive activity balance effects. However, revenues from RES-trade (compared to the reference scenario) highly depend on assumptions like the trading period (2011-2020 versus 2015-2020) or prices for RES-shares. The prices used in our assessment can be found in Annex 1, Table 17 and vary between 70 and 77 €/MWh (moderate price assumptions) depending on the scenario and the year in which the trade occurs. Whether or not a trading period for RES-shares from 2015 to 2020 or from 2011 to 2020 is assumed however does not impact the ranking between scenarios.

To sum it up: From the point of view of the activity balance the B-scenarios perform better than the A-scenarios as in the A-scenarios the trade balance worsens with the RES capacity extension. The effect of CO_2-trade on the overall activity balance is relatively small. In contrast, RES-trade can, depending on the market assumptions, significantly change the balance, but does not in our case change the ranking of the scenarios.

6.3 Comparison of public and total expenditures

Public expenditures (investment costs, subsidies, maintenance cost) vary considerably among the analyzed scenarios. Generally, the B-scenarios require higher public funds. However, while public expenditures in A-scenarios only include subsidies for RES-expansion needed by private investors, public expenditures in energy efficiency measures include also investment costs for instance for thermal insulation in public buildings. Therefore, the high public expenditures in the B-scenarios also add value to public assets.

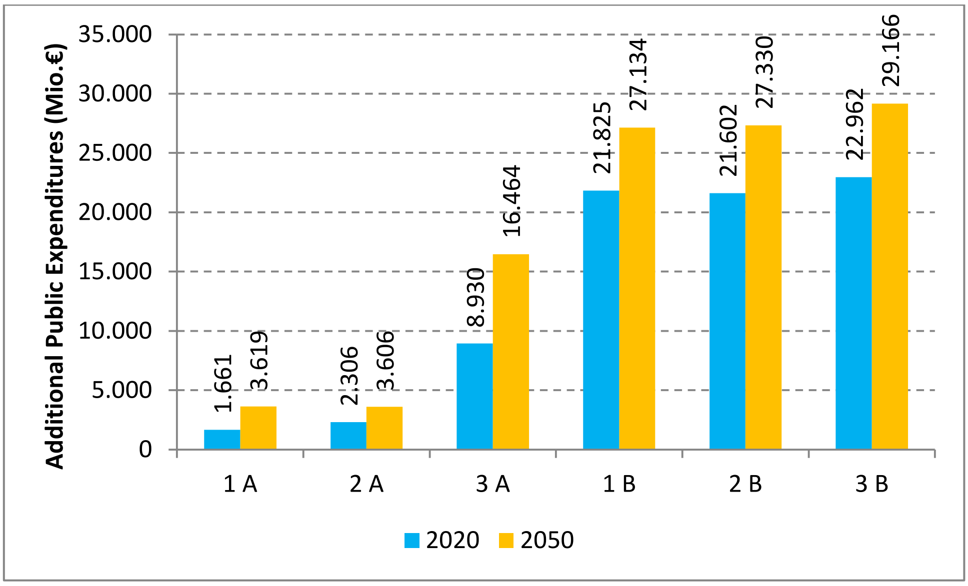

Figure 39: Additional public expenditures compared to the reference scenario within the time periods 2011-2020 and 2011-2050

Figure 39 shows that the needed public expenditures are far higher in the B-scenarios. The increase in public expenditures in the B-scenarios from 1B to 3B is small, whereas this increase is significant within the A-scenarios – especially from 2A to 3A. This increase is mainly caused by intensified PV capacity extension in 3A compared to 2A. It can also be observed from Figure 39 that only approximately one half of required public funds (subsidies) in the A-scenarios are needed until 2020 – the rest has to be raised after 2020.

In contrary to that, in B-scenarios the bulk of required public funds (for investments in energy efficiency measures) have to be raised before 2020.[81]

Another important criterion for assessing scenarios is the “profitability” of measures, which means whether investment costs for measures can be balanced by savings in operating costs. In the short term (until 2020), total investment and operating costs (public and private) of A-scenarios are much lower than net-costs incurred in the B-scenarios (Figure 40). The reason is that initially high investment costs in the B-scenarios for energy efficiency measures cannot be balanced by cost savings due to energy savings within the relatively short period until 2020. In other words: monetary savings by a reduction of energy demand cannot pay back for high initial investment costs in the short term.

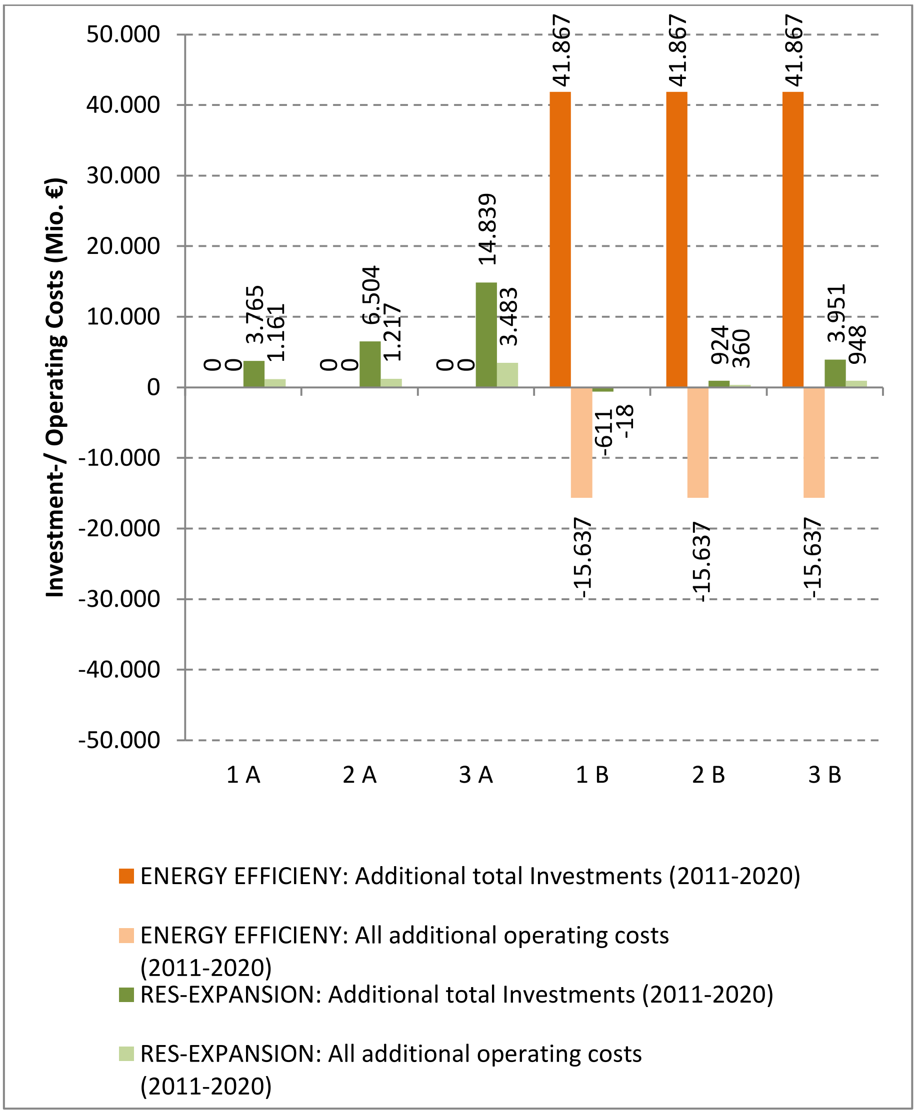

Figure 40: Additional Investment- and operating costs for energy efficiency and RES-expansion measures (short term consideration 2011-2020), compared to the reference scenario

[81] Cost after 2020 in scenarios with increased energy efficiency mainly evolve due to maintenance activities in public transport

Figure 40 illustrates the high additional investment cost in the B-Scenarios. The "additional operating costs" include e.g. maintenance costs and cost savings due to energy savings[82]. However, in the long term (until 2050) the picture changes (Figure 41). Whereas in the A-scenarios rising costs for subsidizing partially non-competitive RES-technologies have to be added to investment costs, investment costs and additional operating costs in the B-scenarios are overcompensated by energy cost savings caused by energy efficiency measures. This means, in the long term only in B-scenarios costs are entirely balanced by induced cost savings.

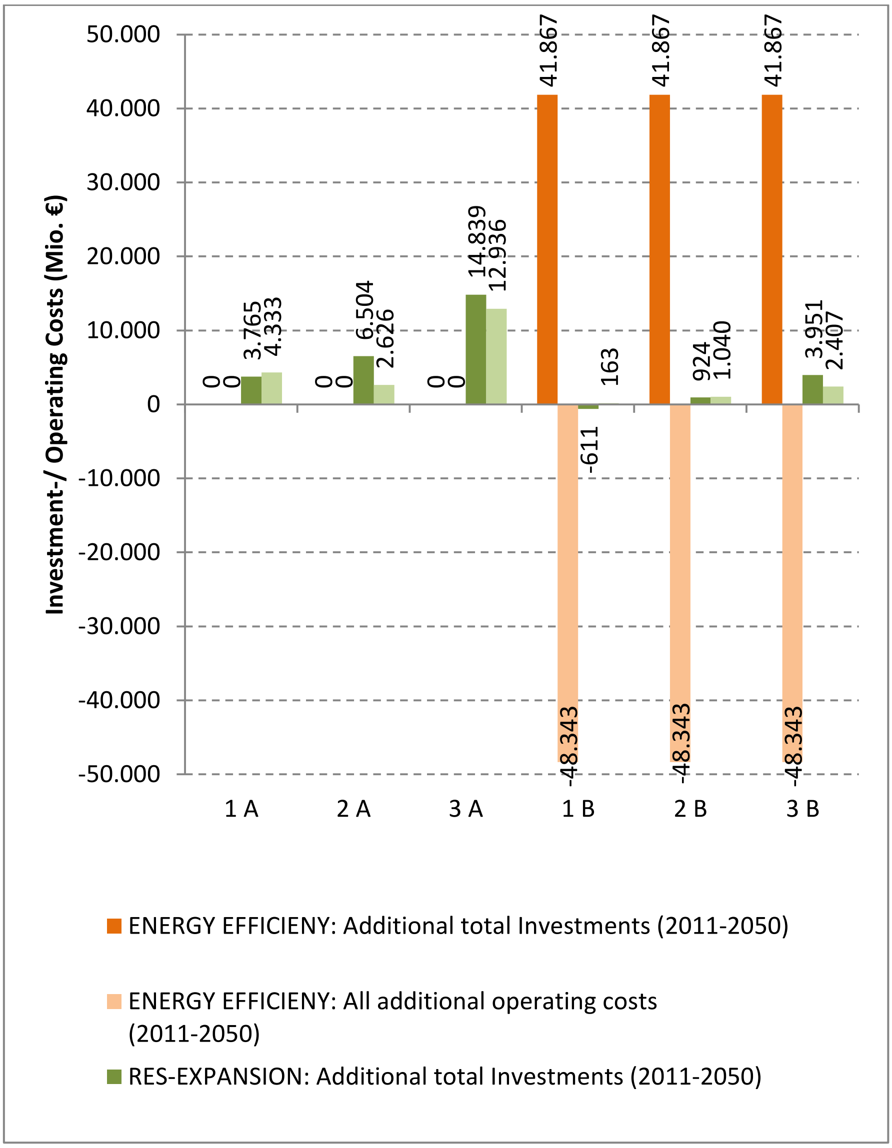

Figure 41: Additional Investment- and operating costs for energy efficiency and RES-expansion measures (long term consideration 2011-2050), compared to the reference scenario

[82] Also called "additional generation costs" in this study. For additional generation costs of RES see Annex 3.

6.4 Integrating the results

The comparisons in the previous chapters reveal that A-scenarios have higher overall welfare effects (= consumption possibilities) whereas B-Scenarios result in a better activity balance. Also, A-scenarios require lower funds in the short term, whereas only in B-scenarios investment and operating costs are entirely paid back by energy costs savings. In this section, we combine the different results and draw conclusions on the overall strengths and weaknesses of the assessed scenarios.

The figures below show the total welfare effects as well as the activity balance (compared to the reference scenario) for all six assessed cases. Figure 42 assumes RES-trade from 2011 to 2020 and Figure 43 from 2015 to 2020. RES-trade from 2015-2020 has been chosen as default for the conclusions of the integrated assessment in order to take into account that it may take a couple of years until a functioning RES market is established.

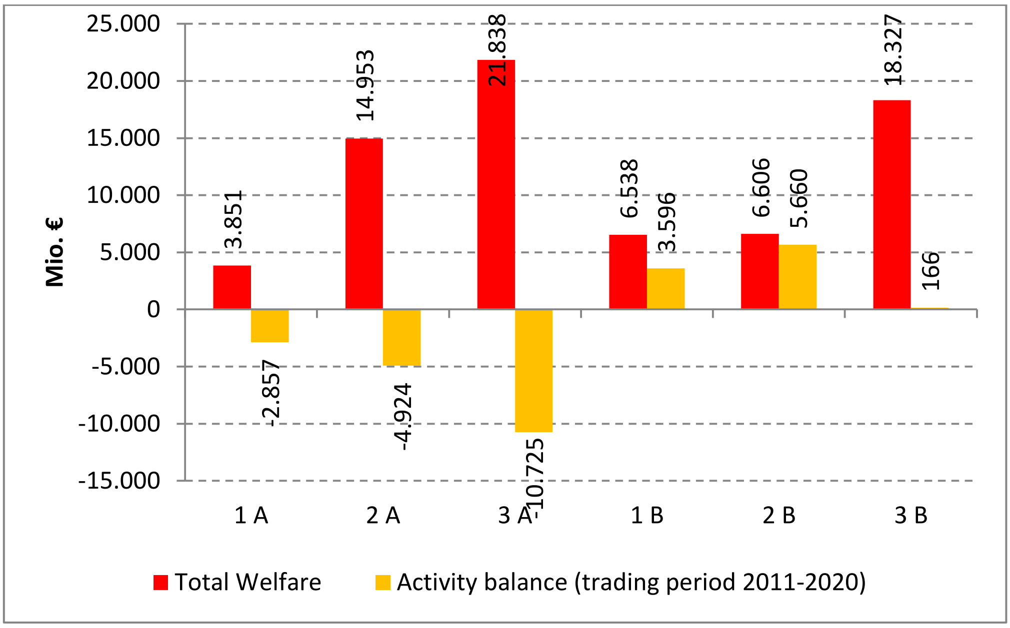

Figure 42: Total welfare effects adjusted by total trade effects up to 2050 compared to the reference scenario (RES trading period 2011-2020)

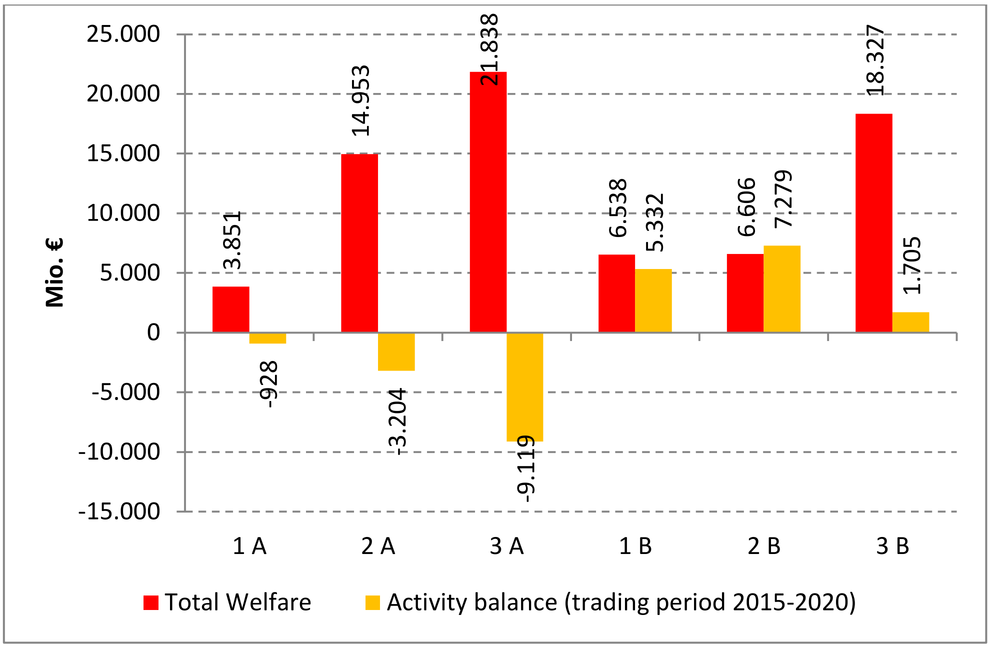

Figure 43: **Total welfare effects adjusted by total trade effects up to 2050 compared to the reference scenario (RES trading period 2015-2020)**

Based on the integrated analyses of welfare and activity balance effects in Figure 43 and the results of chapter 6 on public and total expenditures we draw the following conclusions:

- An underachievement of the Austrian RES target (reference scenario and 1A) is the least desirable option from an economic point of view.
- While a moderate increase of the RES support (from 1A to 2A or from 2B to 3B) has high welfare gains, the negative effects on the activity balance are comparably low.
- Moving from moderate[83] RES-support to strong RES support (2A to 3A) leads to a strong welfare increase, however the welfare increase is accompanied by a significant negative impact on the activity balance. Because these two effects are in the same magnitude, we cannot see a clear preference for 2A or 3A based only on welfare and activity balance effects. However, the need for public subsidies strongly increases when moving from 2A to 3A.
- The effects of purchasing or selling RES shares in case of an under- or overachievement depend on the market assumptions but do in none of the analyzed scenarios lead to a change of the overall ranking of the scenarios.
- Achieving or over-achieving the Austrian RES-target with the B-scenarios requires significantly higher public funds than with the A-scenarios. Most of these funds would have to be provided until 2020 due to the high investment costs of energy efficiency measures. However in the long-term (2011-2050) – taking long-term savings of energy efficiency measures into consideration (discount rate 2.5%) – only in scenarios, which include energy efficiency measures (B-scenarios) investment costs are paid off whereas in the A-scenarios costs are not paid off by revenues (savings in operating costs).

[83] „Moderate“ increase as compared to current RES support

The role of the cooperation mechanisms for the different scenarios

The integrated assessment shows that CO_2-trade plays a minor role as compared to other economic parameters. In contrast, the magnitude of revenues from RES trading substantially contributes to the benefits of reaching or overachieving the national 2020 RES target domestically. In the analyzed scenarios and under the explained market assumptions, the magnitude of RES trading partly exceeds or is comparable to the trade balance effects. While in case of underachieving the RES target RES purchases are necessary, the scenarios leading to exact achievement or overachievement indicate high forgone revenues if the mechanisms are not used (even at moderate assumed price levels for RES trades). This shows the importance of considering participation in the cooperation mechanisms. Of the different cooperation mechanisms statistical transfer corresponds most to the model assumptions because a transfer of existing surpluses but not project-based mechanism has been assumed.

To sum it up: The criteria-based assessment showed that a domestic underachievement of Austria's 2020 RES target and purchase of RES shares to meet the targets is not a beneficial option from an economic point of view. A domestic achievement or overachievement of Austria's RES target is more advantageous due to its domestic welfare effects. For exactly meeting the Austrian RES-target, a priorization of either scenario 2A or 2B is difficult because their specific advantages and disadvantages are not directly comparable. However, taking the long-term view we see a slight preference for scenario 2B. The analysis suggests that the economically most beneficial pathway is an over-achievement of the Austrian RES target. From the analysed scenarios this should be accomplished with 3B rather than 3A. The main reason is the far better total welfare effects if adjusted by the activity balance.

Over-achieving the RES-target with 3B however requires relatively high additional amounts of public and private funds in the short term (2011-2020). However, in the long term (2011-2050), cost savings due to energy saving induced by the investments over-balance expenditures in the B-scenarios, whereas in the A-scenarios costs are not paid off by revenues.

7 Conclusions

While Austria has already agreed on a comprehensive set of measures to meet its 2020 RES target, the assessment of the different scenarios conducted within this project reveals that there may still exist additional opportunities for Austria's energy policy.

The integrated assessment of the project results demonstrates that the different scenarios for meeting or over-achieving Austria's RES target have different economic advantages and drawbacks that also depend on the discount rate applied and therefore on societal preferences regarding future costs and revenues. Moderately increasing the current support for RES (i.e. providing additional support for rather cost-efficient RES technologies) would yield high macroeconomic benefits in the short and medium term. A strong increase of the current RES support (providing additional support also to less cost-efficient RES technologies) would lead to a strong welfare increase, however accompanied by a significant negative impact on the activity balance. Energy efficiency measures, on the other hand, would lead to strong cumulated external benefits in the long-term through the reduction of energy use that leads to a reduction of air pollutants.

Based on the results of this project it can be concluded that a domestic underachievement of Austria's 2020 RES target and, consequently, a purchase of required RES volumes via cooperation mechanisms cannot be recommended from an economic viewpoint. For achieving the committed 34% RES-target by 2020 in Austria the results suggest a mix of a strong domestic energy efficiency policy package reducing final energy demand by 150 PJ by 2020 and a few additional incentives to increase RES deployment above targeted levels, such as increasing of budgetary caps for RES electricity or enhanced stipulation of RES in the heat sector. An overachievement of Austria's RES target (up to 36%) represents the most beneficial option among all assessed scenarios from an economic point of view if it is realized with a moderate increase of current RES support (beyond just increasing current budgetary caps, providing additional support for rather cost-efficient RES technology options in Austria) and a strong energy efficiency policy package long-term domestic macroeconomic and external effects are considered. Such an overachievement of the RES target may also be an appropriate strategy for Austria to hedge against unforeseeable changes in the economic framework (e.g. a higher economic and energy demand growth than projected (reducing the share of RES) or implementation risks of planned RES or energy efficiency measures. At the same time, an overachievement of the RES target would give Austria the opportunity to sell RES volumes to other EU Member States by 2020 and potentially also in the years before 2020 whenever surpluses occur via statistical transfer. In addition to generating income from Statistical Transfer, Austria might also allow for renewable energy investments by other countries in the framework of joint projects. This may improve the point of departure for post-2020 targets by increasing Austria's total renewable energy production well in time. However in contrast to statistical transfers, joint projects represent a long-term commitment to (virtually) export RES which should only be followed if Austria remains to be well on track to fulfill its domestic target. At the same time, given that Austria does not depend on the cooperation mechanisms in order to meet its target, joint support schemes may not have sufficient benefits which would justify their potentially high transaction costs, in particular for the short timeframe till 2020.

Overall, the market for virtual RES trade generally still faces significant uncertainties and is difficult to predict. Experiences with the flexible Kyoto mechanisms to which the cooperation mechanisms have parallels have shown that the high number of factors impacting the success of a mechanism makes it extremely difficult to predict the mechanisms' actual use. Anticipated as supply-demand balances may provide an indicator of future market dynamics but other factors, such as institutional or administrative barriers, may significantly influence these in practice.

Apart from the focus on Austria, this project also considered the European perspective: intensified cooperation between Member States in achieving their 2020 RES targets would allow to reduce the cost burden on the EU level significantly: Annual European support expenditures for RES-electricity for example can be decreased by several billion € in 2020. For Austria such a European cost-minimization would imply an overachievement of its target. The report therefore concludes that an overachievement of Austria's RES target economically makes sense from both an Austrian and a European perspective. Moreover, such a strategy may serve as a safeguard against unpredictable changes and could lay the foundation for future RES target achievements. Thus, a strategy aiming an overachievement of Austria's RES target would contribute to an economically attractive and future-oriented pathway for Austria's RES policy while facilitating RES cooperation across the European Union.

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9 Annexes

Annex 1: Numerical Green-X model results for Austria

The following Tables (11 to 20) show the numerical values of result discusses in chapter 3 (as shown in graphs in Figures 7 to 16).

Table 11: Resulting RES share in (sector) gross final energy demand by 2020 [%]

RES share in sectoral gross final energy demand by 2020 [%]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	65,8%	69,2%	72,8%	79,2%	66,6%	71,7%	72,6%
RES-Heat	28,5%	30,2%	33,5%	34,7%	31,7%	31,6%	35,3%
Biofuels	9,6%	9,4%	9,4%	9,4%	9,6%	9,5%	9,5%
RES total	30,2%	31,8%	34,0%	36,0%	32,9%	34,0%	36,0%

Table 12: Resulting total deployment of new (2011 to 2020) RES installations [TWh] in Austria

Deployment by 2020 in absolute terms [TWh]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	51,0	53,7	56,5	61,4	49,4	53,2	53,8
RES-Heat	47,3	50,1	55,4	57,5	46,5	46,4	51,8
Biofuels	9,4	9,3	9,3	9,3	7,9	7,8	7,8
RES total	107,7	113,0	121,2	128,1	103,8	107,3	113,4

Table 13: Per sector comparison of the resulting deployment of new (2011 to 2020) RES [TWh] in Austria for all assessed cases

Deployment of new (2011 to 2020) RES [TWh]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	6,2	8,9	11,7	16,6	4,8	8,6	9,3
RES-Heat	26,0	28,8	34,1	36,2	25,4	25,3	30,7
Biofuels	4,5	4,4	4,4	4,4	3,0	2,9	2,9
RES total	36,7	42,1	50,2	57,2	33,2	36,8	42,9

Table 14: Technology breakdown of energy production from new (2011 to 2020) RES [TWh]

Technology breakdown of energy production from new (2011 to 2020) RES [TWh]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
Biogas electricity	0,75	0,75	0,03	0,76	0,74	0,01	0,01
Solid biomass electricity	2,15	3,31	3,54	4,48	1,89	2,86	2,72
Biowaste electricity	0,48	0,55	0,54	0,54	0,43	0,54	0,54
Geothermal electricity	0,00	0,00	0,05	0,05	0,00	0,00	0,00
Hydro large-scale	0,85	0,88	0,93	0,93	0,50	0,93	0,93
Hydro small-scale	1,21	1,21	2,69	2,69	0,44	1,61	1,61
Photovoltaics	0,44	1,82	0,58	2,90	0,44	0,58	0,87
Wind onshore	0,36	0,36	3,32	4,21	0,36	2,06	2,59
Biogas heat (grid)	0,60	0,60	0,00	0,60	0,60	0,00	0,00
Solid biomass heat (grid)	5,67	7,01	5,65	5,79	5,00	5,44	5,11
Biowaste heat (grid)	0,82	0,96	0,96	0,96	0,75	0,96	0,96
Geothermal heat (grid)	0,18	0,18	0,18	0,18	0,18	0,18	0,18
Solid biomass heat (decentral)	17,89	18,80	24,92	23,61	17,95	17,63	22,74
Solar thermal heating and hot	0,00	0,17	0,67	2,08	0,00	0,00	0,00
Heat pumps	0,82	1,07	1,76	2,97	0,93	1,07	1,70
1st generation biofuels	0,33	0,33	0,33	0,33	0,33	0,33	0,33
2nd generation biofuels	0,21	0,25	0,25	0,25	0,21	0,25	0,25
Biofuel imports	3,95	3,82	3,82	3,82	2,45	2,34	2,34

Table 15: Comparison of cumulative capital expenditure for new (2011 to 2020) RES installations in Austria for all assessed cases [Billion €]

Cumulative (2011 to 2020) capital expenditures for new (2011 to 2020) RES [Billion €]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	6,2	9,8	9,8	17,3	5,5	7,8	8,8
RES-Heat	10,8	11,6	14,2	16,2	10,9	10,0	12,4
Biofuels	0,2	0,2	0,2	0,2	0,2	0,2	0,2
RES total	17,2	21,6	24,3	33,7	16,5	18,0	21,4

Table 16: Comparison of the required cumulative support expenditures for new (2011 to 2020) RES installations [Billion €]

Cumulative (2011 to 2020) support expenditures for new (2011 to 2020) RES [Billion €]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	1,3	3,1	2,9	7,4	1,4	2,1	2,6
RES-Heat	1,9	2,1	3,0	6,2	1,9	1,0	2,1
Biofuels	0,3	0,3	0,3	0,3	0,2	0,2	0,2
Expenses for / earnings through cooperation mechanisms (moderate)	3,5	0,5	-1,9	-3,8	-0,8	-2,0	-3,4
Expenses for / earnings through cooperation mechanisms (expensive)		0,7			-4,4		
RES total excl. cooperation	3,6	5,5	6,2	13,9	3,5	3,3	4,9
RES total with cooperation (moderate price)	7,0	6,0	4,3	10,1	2,8	1,3	1,4
RES total with cooperation (high price)		6,2			-0,8		

Table 17: Negotiated exchange price per MWh RES generation [€/MWh] for (virtual) RES trade

Negotiated exchange price per MWh RES generation [€/MWh] for (virtual) RES trade	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reference	75,0	75,0	75,0	75,0	75,0	174,0	185,2	182,4	168,0	166,6
Case 1A expensive	75,0	75,0	75,0	75,0	75,0	202,9	214,0	219,2	219,9	224,0
Case 1A moderate	70,4	69,2	69,0	75,0	74,9	71,2	69,0	66,3	64,9	64,6
Case 2A	70,4	69,2	69,0	75,0	74,9	71,2	69,0	66,3	64,9	64,6
Case 3A	70,6	69,4	69,4	75,0	75,0	72,2	70,4	67,9	66,0	64,8
Case 1B expensive	75,0	75,0	75,0	75,0	75,0	178,4	188,1	187,8	177,8	183,5
Case 1B moderate	71,4	71,3	71,8	75,0	75,0	76,7	74,5	70,2	70,2	68,9
Case 2B	71,4	71,3	71,8	75,0	75,0	76,7	74,5	70,2	70,2	68,9
Case 3B	71,3	71,3	71,8	75,0	75,0	77,0	72,3	70,3	70,2	69,0

Table 18: Cumulative additional generation cost for new (2011 to 2020) RES [Billion €]

Cumulative (2011 to 2020) additional generation cost for new (2011 to 2020) RES [Billion €]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	0,9	2,3	1,7	4,6	1,0	1,4	1,7
RES-Heat	0,1	0,1	0,8	0,5	0,1	0,2	0,5
Biofuels	0,3	0,3	0,3	0,3	0,2	0,2	0,2
RES total	1,3	2,7	2,7	5,4	1,3	1,8	2,4

Table 19: Cumulative savings of fossil fuel expenses due to new (2011 to 2020) RES [Billion €]

Cumulative (2011 to 2020) savings of fossil fuel expenses due to new (2011 to 2020) RES [Billion €]	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	1,4	2,1	3,4	4,8	1,1	2,5	2,6
RES-Heat	3,1	3,2	4,2	4,5	3,0	2,8	3,7
Biofuels	0,6	0,6	0,6	0,6	0,4	0,4	0,4
RES total	5,2	5,9	8,2	9,9	4,4	5,7	6,7

Table 20: Cumulative avoidance of CO_2 emissions due to new (2011 to 2020) RES [Mt]

Cumulative (2011 to 2020) avoidance of CO2 emissions due to new (2011 to 2020) RES [Mt	Reference	Case 1A	Case 2A	Case 3A	Case 1B	Case 2B	Case 3B
RES-Electricity	17,2	25,4	41,7	58,7	13,3	31,8	33,5
RES-Heat	25,6	26,3	35,1	36,8	25,2	23,8	31,0
Biofuels	3,0	3,0	3,0	3,0	1,7	1,7	1,7
RES total	45,9	54,7	79,8	98,6	40,1	57,2	66,1

Annex 2: Details on the macroeconomic evaluation

Macroeconomic effects on Single Technologies

The following Figure 44 shows the average macroeconomic effects (welfare, trade balance) of the RES-technologies over the 10-year period and all six scenarios (1A, 2A, 3A, 1B, 2B, 3B).

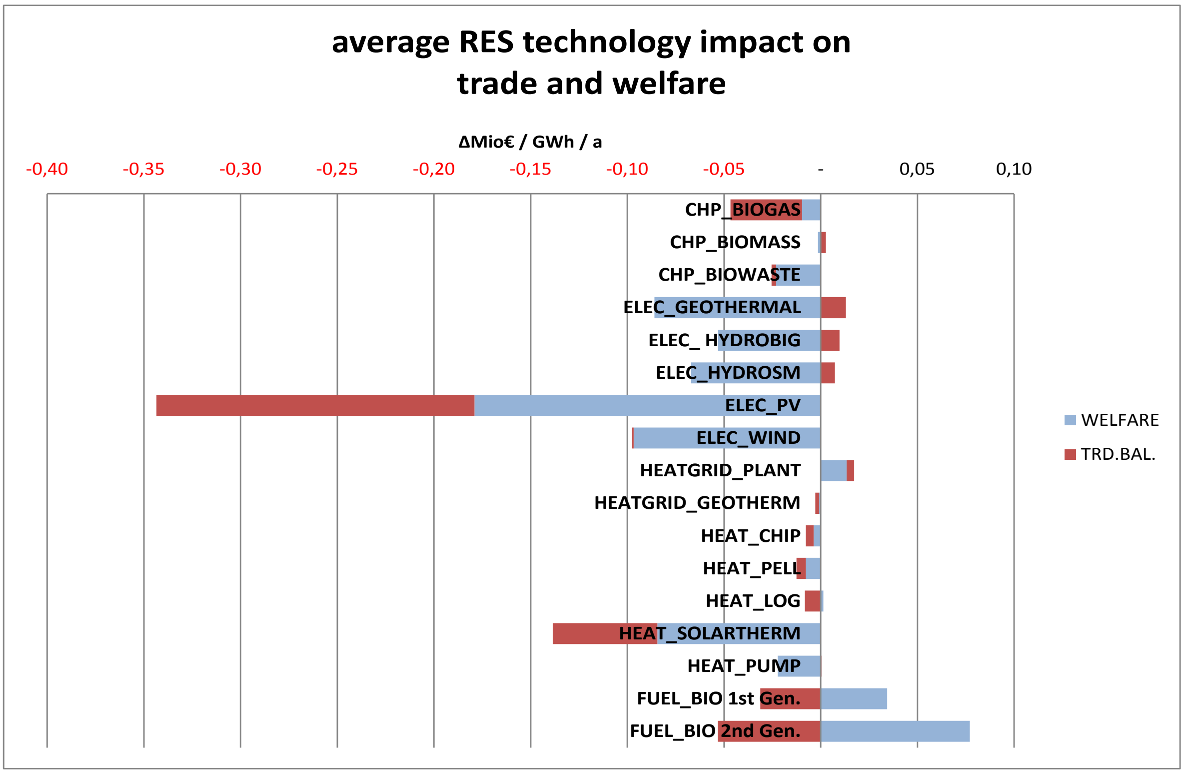

Figure 44: Total cum. welfare effects in detail (2011 – 2020)
Source: Own calculations

This figure describes the average macroeconomic effect of each simulated technology in form of change in Welfare (Change in Welfare was evaluated in form of an income equivalent variation in Million Euros) per produced energy (GigaWattHours) and year (a). In case of the Photovoltaic (PV) technology for instance this means that the average effect of additional Energy produced by PV have a negative effect on welfare (due to the additional generation costs compared to conventional energy production) as well as on the trade balance (due to the high import share of the production). The opposite effect can be seen for the technology "heat plant" where additional produced energy services increase welfare (due to increased labour demand and thus increased wages) and improve the trade balance (due to a reduction of fossil fuels need).

Trade Balance

In the base year for the model runs (2005) Austria has a deficit in balance of trade. The reference scenario is modelled in a way that the deficit tends toward zero until 2050. The following figures display the deviation of this reference development in the scenarios up to 2020 and 2050.

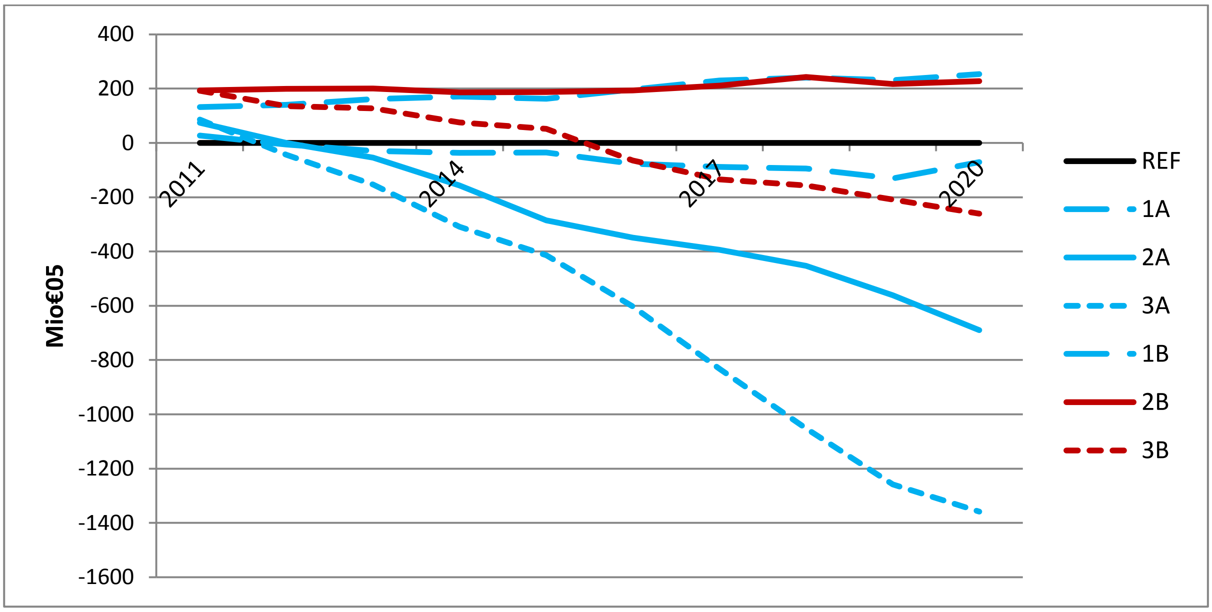

Figure 45: **Change of Trade balance compared to Reference (2011 – 2020)**

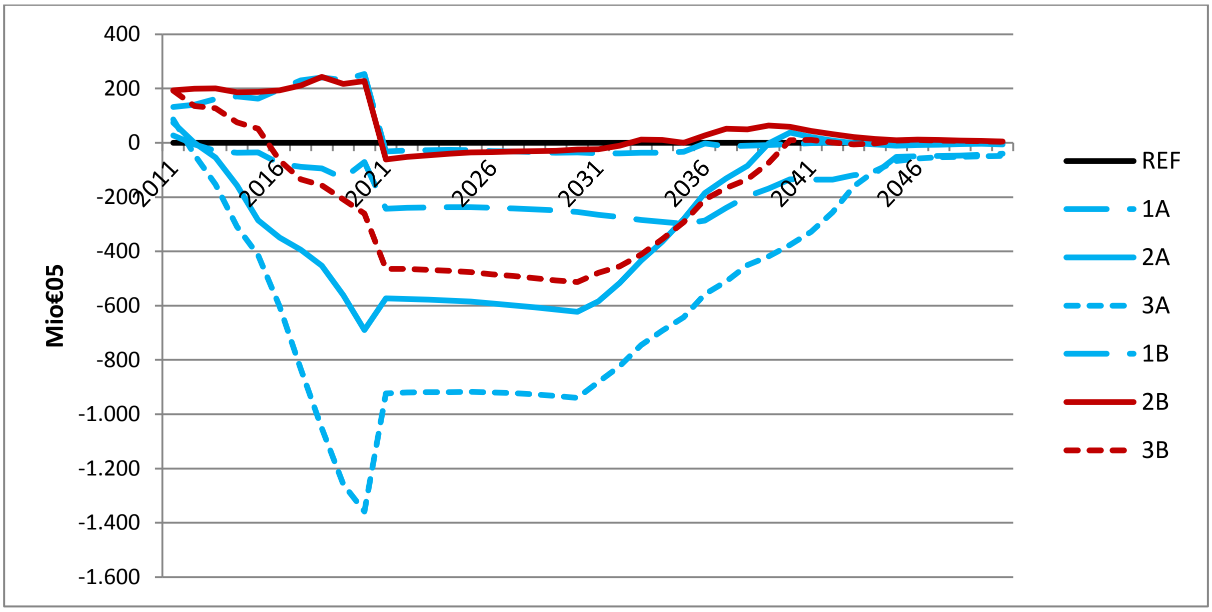

Figure 46: **Change of Trade balance compared to Refernece (2011 – 2050)**

Source: Own calculations

Annex 3: Marginal cost-resource curves for Renewable Energy Technologies in Austria

The core objective of this chapter is to provide an overview of costs and potentials for RES in Austria by means of cost-resource curves. Data on Austria will be contrasted with information for other EU countries. Finally information on costs and potentials of specific RES technologies were combined to determine for illustrative purposes a marginal cost curve for renewable energy production.[84]

While consolidated literature for RES potentials is available for Austria, the associated costs are only applicable in fragments. Here the project contributed to research needs by elaborating consistent cost-resource curves for Austria. The derived database represents a core input for the subsequent modelling of renewable energy deployment with the Green-X model in chapter 5. The database of the Green-X model contains already information on potentials and costs for RES technologies in Europe. Based on a literature survey and on work-related to the derivation of input-output data for RES, the original Green-X data was updated specifically for Austria.

Assessment of the potential for renewable energy in Austria using static marginal cost curves

A broad set of different renewable energy (RE) technologies is existing. Obviously, for a comprehensive assessment of the future development of RE technologies it is of crucial importance to provide a detailed investigation of the country-specific situation, e.g. the potential of specific technologies taking a possible regional distribution and corresponding costs into consideration. This section discusses potentials and costs for RE technologies building on in-depth assessments of several studies, specifically Nakicenovic and Schleicher et al. (2007) and Resch et al. (2009) while for costs the study by Klessmann et al. (2010) was also used. The derived data on realisable mid-term production potential (up to the year 2020) for RE technologies and corresponding costs match with the requirements of the Green-X model and serve as key input for the subsequent RE policy assessments as well as the accompanying macroeconomic evaluations.

<u>Concepts to define the RES potential:</u>

The possible use of RES depends in particular on the available resources and the associated costs. In this context, the term "available resources" or RES potential has to be clarified. In literature, potentials of various energy resources or technologies are intensely discussed. However, often no common terminology is applied. We use the following terminology:

Theoretical potential: For deriving the theoretical potential general physical parameters have to be taken into account (e.g. based on the determination of the energy flow resulting from a certain energy resource within the investigated region). It represents the upper limit of what

[84] Please note that the derived cost-resource curve offers only a schematic depiction of the feasible future potential for RES in Austria. Within the Green-X model and the conducted scenario work, respectively, a more detailed characterisation and policy-dependent exploitation of RE technologies is conducted in a dynamic context. Thereby, in contrast to the static depiction, the feasible potential and related cost of a specific RE technology in a given year depend on the progress achieved in previous years.

can be produced from a certain energy resource from a theoretical point-of-view – of course, based on current scientific knowledge.

Technical potential: If technical boundary conditions (i.e. efficiencies of conversion technologies, overall technical limitations e.g. as the available land area to install wind turbines as well as the availability of raw materials) are considered the technical potential can be derived. For most resources the technical potential must be considered in a dynamic context, considering e.g. R&D induced improved conversion technologies, increasing the technical potential.

Realisable potential: The realisable potential represents the maximal achievable potential assuming that all existing barriers can be overcome and all driving forces are active. Thereby, general parameters as e.g. market growth rates and planning constraints are taken into account. It is important to mention that this type of potential must be seen in a dynamic context, i.e. the realisable potential has to refer to a certain year.

Mid-term (2020) potential: The mid-term potential is equal to the realisable potential for the year 2020.

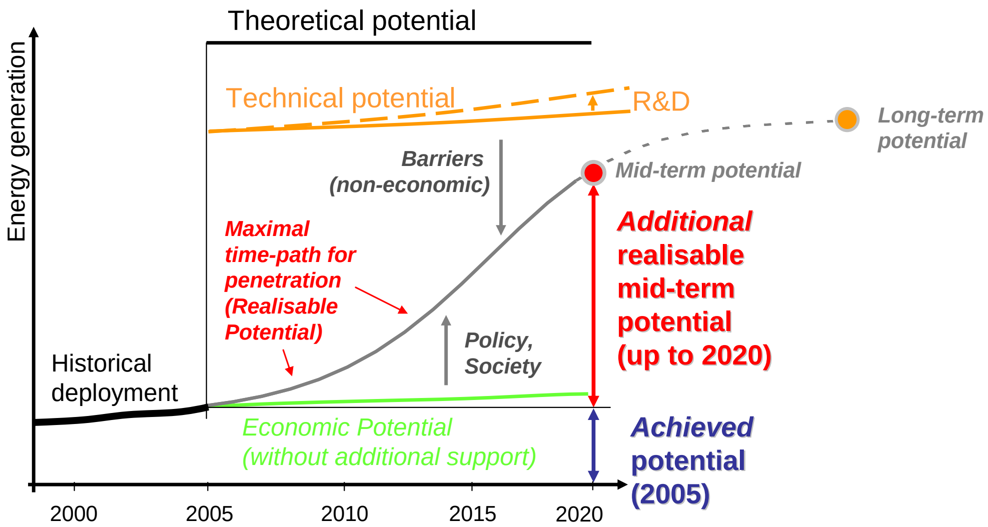

Figure 47: Methodology to assess the mid-term potential

Figure 47 shows the concept to assess the realisable mid-term potential up to 2020

A broad set of literature is available assessing the potential for renewable energy sources and/or corresponding conversion technologies in Austria. Following the classification discussed before we focus on the comparison of realisable potentials up to 2020, whereby an overview on the outcomes of the literature survey performed is given in Table 21. The overall realisable potential for RES in Austria up to 2020, expressed in terms of final energy is estimated to be in a range from 375 to 559 PJ. As shown in Table 21 this high range results in particular from the uncertainty related to bioenergy, representing the key contributor to Austria's renewable energy supply at present. For the future potential of bioenergy estimates differ substantially, ranging from 187 to 281 PJ (final energy). One major difference between the studies considered refers to feedstock imports – i.e. the lower value does not include any imports, while the upper value incorporates a feasible amount of such imported resources (in line with past/current trends). A significant difference regarding the 2020 potentials is also observable for other RE-categories – i.e. photovoltaics, wind energy, solar thermal heat and geothermal energy. However, due to the far lower absolute potential, these differences have a lower impact on the overall RES potential in Austria. Table 21 also includes data to be used for the subsequent model-based analysis with the Green-X model (chapter 5). The figures are generally on the upper boundary of RES potential estimates as for the Green-X database on potentials and cost for RES in contrast to several other studies no economic restrictions were applied – such constraints will however be reflected in the subsequent Green-X scenario work.

Table 21: Overview of studies assessing the potential for renewable energy in Austria in 2020

Comparison of potential studies *(all data expressed in PJ)*	*Bioenergy (primary energy)*	Bioenergy (final energy)	Hydro-power	Heat pumps, ambient heat	Photo-voltaics	Solar thermal heat	Wind energy	Geo-thermal energy
VEÖ Perspektiven regenerativer Energien inÖsterreich	*~215-225*	195	148-159		0.4	14	26.3	20
VEÖ Biomasseaufkommen in Öster-reich	*~210*	186						
BMLFUW Erneuerbare Energie - Potentiale in Österreich	*293.0*	272.0	148-159	25-27	7.2-10.8	26-28	26-26.5	
WIFO Evaluierung des Biomasse-potentials inÖsterreich	*262.0*	243.2						
Energy Agency Ökostromgesetz – Evaluierung und Empfehlungen							26.3	
EEG GreenX Datenbank	***298 (incl. imports)***	**280.7**	**160.9**	**26.5**	**16.0**	**23.1**	**16.2**	**4.2**
e-control Evaluierung der Ökostrom-entwicklung und Ökostrompotenziale			152			13	9.7-11.7	
WKÖ Wärme und Kälte aus Erneuerbaren in 2030				23-27		5.5-10.5		
Landwirtschaftskammer Österreich Nationaler Aktionsplan für EE	*198.9*	186.7						
RES (total) mimum	***198.9***	**184.6**	**148.0**	**23.0**	**0.4**	**5.5**	**9.7**	**4.2**
RES (total) maximum	***295.0***	**280.7**	**160.9**	**27.0**	**16.0**	**28.0**	**26.5**	**20.0**

Source: based on Nakicenovic and Schleicher et al. (2007), Green-X database

Future potentials for RE - technologies in EU countries

In this section an illustration of future potentials for RE technologies in the European Union is provided, putting the above assessed RES potentials for Austria in the EU context. Consolidated outcomes on Europe's RES potentials are discussed as derived from several studies in this area.

> *Assessment of RES potentials in Europe – Methodological approach*
>
> *From a historical perspective the starting point for the assessment of realisable mid-term potentials was geographically the European Union as of 2001 (EU-15), where corresponding data was derived for all Member States initially in 2001 based on a detailed literature survey and a development of an overall methodology with respect to the assessment of specific resource conditions of several RES options. In the following, within the framework of the study "Analysis of the Renewable Energy Sources' evolution up to 2020 (FORRES 2020)" (see Ragwitz et al., 2005) comprehensive revisions and updates have been undertaken, taking into account reviews of national experts etc. Consolidated outcomes of this process were presented in the European Commission's Communication "The share of renewable energy" (European Commission, 2004). Within the scope of the futures-e project (2006 to 2008 (see http://www.futures-e.org) an intensive feedback process at the national and regional level was established. A series of six regional workshops was hosted by the futures-e consortium within 2008. The active involvement of key stakeholders and their direct feedback on data and scenario outcomes helped to reshape, validate and complement the previously assessed information.*

In the following figures (Figure 48, Figure 49, Figure 50, Figure 51) it is illustrated to what extent RES may contribute to meet the final energy demand within the European Union (EU-27) up to 2020 by considering the specific resource conditions and current technical conversion possibilities[85] as well as realization constraints in the investigated countries. Only the domestic resource base was taken into consideration – except for forestry biomass, where a small proportion of the overall potential refers to imports from abroad.[86]

Please note that within this illustration the future potential for all biomass feedstock categories considered is pre-allocated to feasible technologies and sectors based on simple rules of thumb.[87] In contrast to this, within the Green-X model no pre-allocation to the sectors electricity, heat or transport was undertaken as technology competition within and across sectors is well reflected in the applied modelling approach.

Furthermore, only a concise overview is given of the overall 2020 potentials in terms of final energy by country, while for a detailed discussion of the provided data we refer to Resch et al. (2009).

[85] The illustrated mid-term potentials describe the feasible amount of e.g. electricity generation from combusting biomass feedstock considering current conversion technologies. Future improvements of the conversion efficiencies (as typically considered in model-based prospective analyses) would lead to an increase of the overall mid-term potentials.

[86] 12.5% of the overall forestry potential or approximately 30% of the additional forestry resources that may be tapped in the considered time horizon refer to such imports from abroad.

[87] Simplified allocation rules comprise for example that in forestry the energetic potential of complementary fellings is equally pre-allocated to the sectors of heat and electricity.

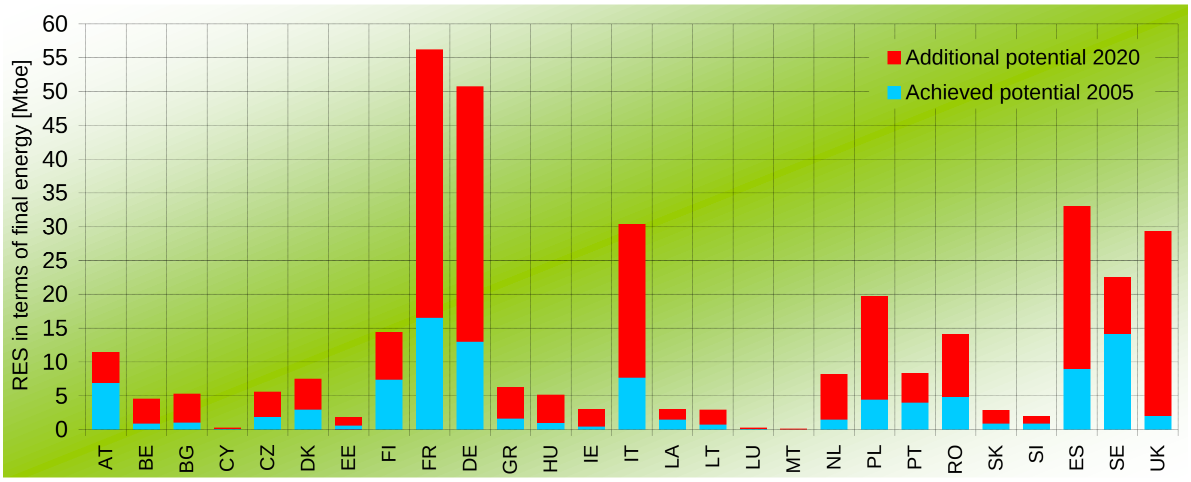

Figure 48: **Achieved (2005) and additional 2020 potentials for RES in terms of final energy demand for all EU Member States (EU27) – expressed in absolute terms**
Source: Green-X database

Summing up all RES options applicable at country level Figure 48 shows the achieved potential (in the year 2005) and the additional mid-term potential for RES in all EU Member States. Potentials are thereby expressed in absolute terms. Member States possessing large RES potentials are e.g. France, Germany, Italy, Poland, Spain, Sweden and the UK. In order to illustrate the situation in a suitable manner for small countries (or countries with a lack of RES options available), Figure 49 offers a similar illustration in relative terms, expressing the 2020 potential as share of gross final energy demand.

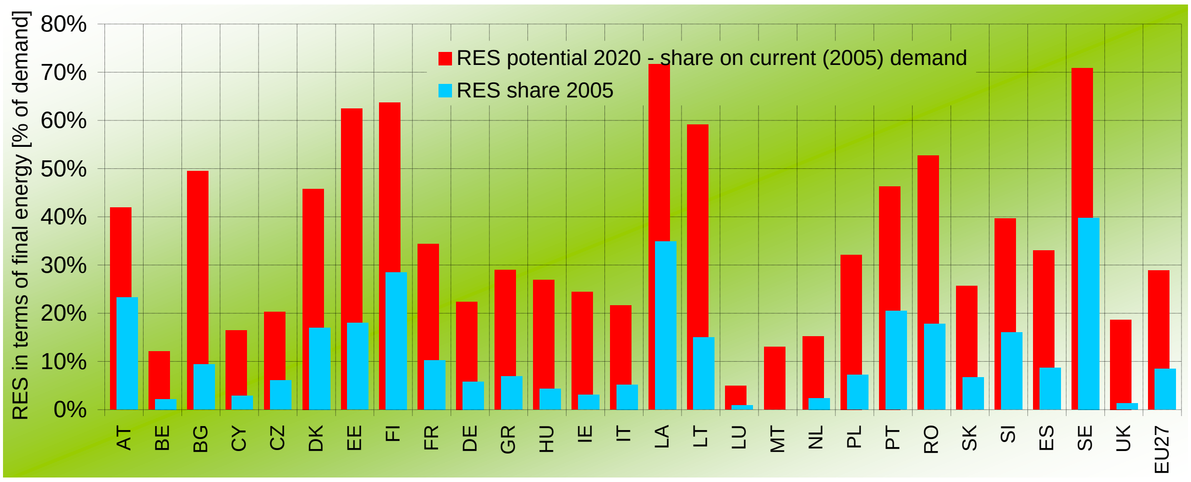

Figure 49: **Achieved (2005) and 2020 potentials for RES in terms of final energy for all EU Member States (EU27) – expressed in relative terms, as share on gross final energy demand**
Source: Green-X database

The overall 2020 potential for RES in the European Union is 349 Mtoe, corresponding to a share of 28.5% of the overall current gross final energy demand. This indicates the high level of ambition of the EU target of meeting 20% RES by 2020[88]. In general, large differences between the individual countries with regard to the realized and the feasible future potentials for RES are observable. For example, Sweden, Latvia, Finland and Austria represent countries with a high RES share already at present, while Bulgaria and Lithuania offer the highest additional potential compared to their current energy demand. However, in absolute terms both are rather small compared to other countries large in size or, more precisely, with large 2020 RES potentials.

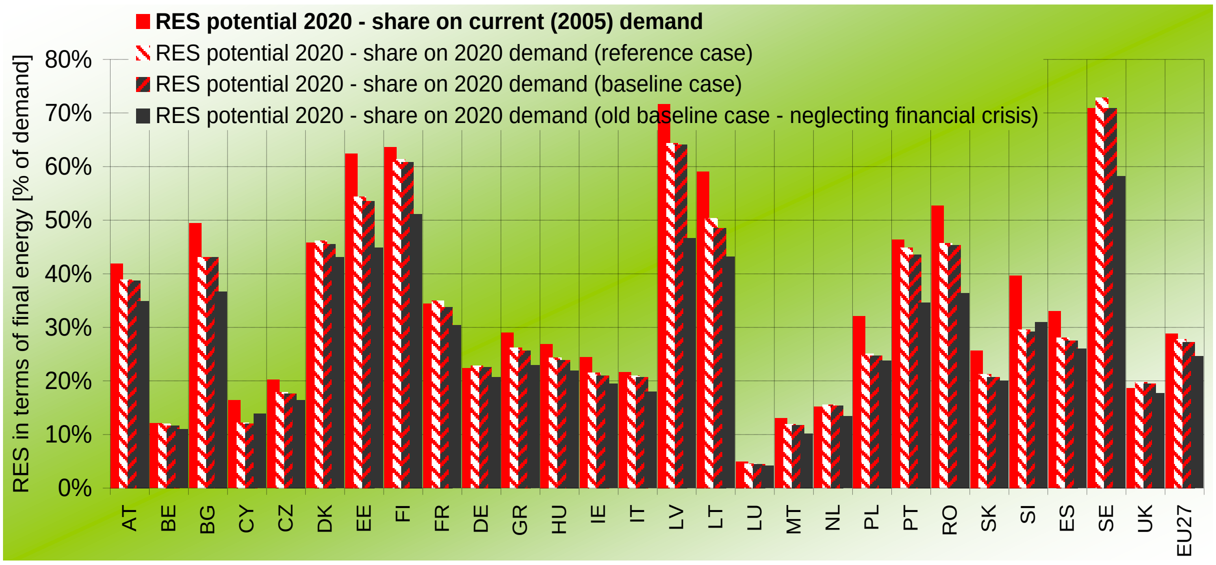

Figure 50: The impact of demand growth - 2020 potential for RES as share on current (2005) and expected future (2020) gross final energy demand.
Source: Green-X database

Figure 50 (above) relates derived RES potentials to the expected future energy demand. More precisely, it shows at country level the total realizable 2020 potentials[89] for RES as share of final energy demand in 2005 and in 2020, considering three different demand projections – i.e. a recent (as of 2009) and an older (2007) baseline case, both assuming a continuation of past trends and a reference scenario where a moderate demand reduction occurs as a side-effect of proactive energy policy measures tailored to meet the 2020 RES and GHG commitments.[90]

Both baseline trend projections differ with respect to the incorporation of the financial crisis. While the recent baseline case (as of 2009) takes into account the lately observable decrease of energy consumption within all energy sectors as a consequence of the financial crisis, the older version (as of 2007) obviously ignores it. This affects the feasible RES

[88] It is worth to mention that biofuel imports from abroad are not considered in this depiction. Adding such in a size of 5% of the current demand for diesel and gasoline (i.e. half of the minimum target of 10% biofuels by 2020) would increase the overall RES potential by 1.2%.

[89] The total realisable mid-term potential comprises the already achieved (as of 2005) as well as the additional realisable potential up to 2020.

[90] In order to ensure maximum consistency with existing EU scenarios and projections, data on current (2005) and expected future energy demand was taken from PRIMES. The used PRIMES scenarios are:

- the Baseline Scenario as of December 2009 (NTUA, 2009)
- the Reference Scenario as of April 2010 (NTUA, 2010)

Please note that this data (and also the depiction of corresponding RES shares in demand) may deviate from actual statistics.

contribution in relative terms – i.e. the RES share on final energy demand - significantly: if demand increased as expected under 'business as usual' conditions before the crisis, a full exploitation of the 2020 potential for RES would correspond to a share of 25% on EU's gross final consumption (by 2020). In contrast to that, the new baseline trend indicates a maximum RES-share of 27% by 2020. Obviously, also financing conditions for RES projects have been affected by the crisis, but this is subject of the subsequent model based scenario assessment in chapter 5.

The difference between both recent demand projections (reference and baseline case, see chapter 2 for details) is of comparative smaller magnitude: only a slightly lower energy demand will arise in 2020 if proactive GHG and RES policies in line with the given policy commitments are implemented in the reference case – i.e. the 2020 potential of all available RES options adds up to 28% when expressed as share of gross final energy consumption by 2020 according to the reference case. Moreover, it can be expected that with additional strong energy efficiency measures a significantly higher RES share would be feasible.

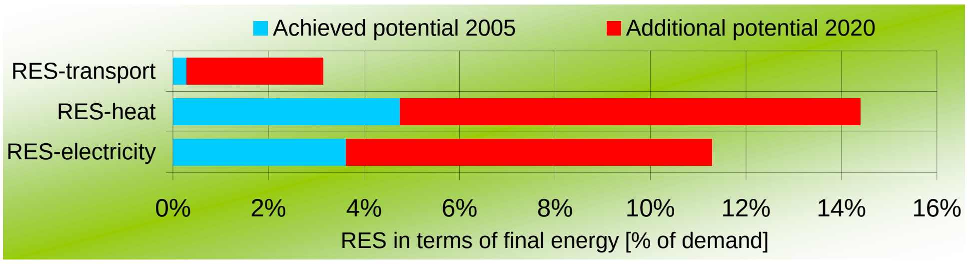

Figure 51: Sectoral breakdown of the achieved (2005) and additional 2020 potential for RES in terms of final energy at EU 27 level – expressed in relative terms, as share on gross final energy demand

Source: Green-X database

Finally, a sector breakdown of the 2020 RES potentials at European level is given in Figure 51. As shown in this figure, the largest contributor to meet future RES targets is the heat sector, where the highest share has already been achieved, but still a large additional amount appears feasible for the near to mid future. The overall 2020 potential for RES-heat is in a size of 14.2% of the current final energy demand, followed by RES in the electricity sector, which may achieve a share of total final energy demand of up to 11.2%. The smallest contribution can be expected from biofuels in the transport sector, which offer, considering solely domestic resources, a potential of about 3.1% of the current final energy demand.

Overview of costs for RE technologies

The economic performance of a specific energy technology determines its future market penetration. In the following, cost assumptions as made in the Green-X database for various RE technologies are discussed and illustrated. Please note that the presented data refer to the year 2009 and are expressed in $€_{2009}$.

> *The Green-X database on potentials and cost for RE technologies in the European Union*
>
> *The Green-X database on potentials and cost for RE technologies in Europe provides detailed information on current costs (i.e. investment - operation & maintenance - fuel and generation cost) and potentials for all RE technologies within each EU Member State. The assessment of the economic parameter and accompanying technical specifications for the various RE technologies builds on a long track record of European and global studies in this area. From a historical perspective the (geographically) starting point for the assessment of realisable mid-term potentials was the European Union as of 2001 (EU-15), where corresponding data was derived for all Member States initially in 2001 based on a detailed literature survey and an expert consultation. In the following, within the framework of the study "Analysis of the Renewable Energy Sources' evolution up to 2020 (FORRES 2020)" (see Ragwitz et al., 2005) and various follow-up activities comprehensive revisions and updates have been undertaken, taking into account recent market developments. In the recently completed EU research project RE-Financing (Klessmann et al. (2010)) again a comprehensive update of cost parameter was undertaken, incorporating recent developments – i.e. the past cost increase mainly caused by high oil and raw material prices, and, later on, the significant cost decline as observed for various energy technologies throughout 2008 and 2009. The process included besides a survey of related studies (e.g. Krewitt et al. (2009), Wiser (2009) and Ernst & Young (2009)) also data gathering with respect to recent RE projects in different countries. Within this study a focus was put to incorporate country-specific trends, specifically for Austria in a correct manner.*

Economic conditions for the various RE technologies are based on both, economic and technical specifications, varying across the EU countries.[91] In order to illustrate the economic figures for each technology Table 22 presents the economic parameters and accompanying technical specifications for RE technologies. Please note that this illustration is done exemplarily for the electricity sector. The Green-X database and the corresponding model use a quite detailed level of specifying costs and potentials. The analysis is not based on average costs per technology. For each technology a detailed cost-curve is specified for each year, based on so-called cost-bands. These cost-bands summarize a range of production sites that can be described by similar cost factors. For each technology a minimum of 6 to 10 cost bands were specified by country. For biomass due to the broad set of conversion technology options as well as related feedstock categories at least 50 cost bands were specified for each year in each country. In the following the current investment costs for RE technologies are described alongside the data provided in Table 22 discussing recent trends of some key technologies.

[91] Note that in the Green-X model the calculation of generation costs for the various generation options is done by a rather complex mechanism, internalized within the overall set of modelling procedures. Thereby, band-specific data (e.g. investment costs, efficiencies, full load-hours, etc.) is linked to general model parameters such as interest rate and depreciation time.

Table 22: Overview of economic-& technical-specifications for new RES-electricity plants

RES-E sub-category	Plant specification	Investment costs	O&M costs	Efficiency (electricity)	Efficiency (heat)	Lifetime (average)	Typical plant size
		[€/kW$_{el}$]	[€/(kW$_{el}$* year)]			**[years]**	[MW$_{el}$]
Biogas	Agricultural biogas plant	2550 - 4290	115 - 140	0.28 - 0.34	-	25	0.1 - 0.5
	Agricultural biogas plant - CHP	2765 - 4525	120 - 145	0.27 - 0.33	0.55 - 0.59	25	0.1 - 0.5
	Landfill gas plant	1350 - 1950	50 - 80	0.32 - 0.36	-	25	0.75 - 8
	Landfill gas plant - CHP	1500 - 2100	55 - 85	0.31 - 0.35	0.5 - 0.54	25	0.75 - 8
	Sewage gas plant	2300 - 3400	115 - 165	0.28 - 0.32	-	25	0.1 - 0.6
	Sewage gas plant - CHP	2400 - 3550	125 - 175	0.26 - 0.3	0.54 - 0.58	25	0.1 - 0.6
Biomass	Biomass plant	2225 - 2995	84 - 146	0.26 - 0.3	-	30	1 – 25
	Co-firing	450 - 650	65 - 95	0.37	-	30	-
	Biomass plant - CHP	2600 - 4375	86 - 176	0.22 - 0.27	0.63 - 0.66	30	1 – 25
	Co-firing – CHP	450 - 650	85 - 125	0.2	0.6	30	-
Biowaste	Waste incineration plant	5500 - 7125	145 - 249	0.18 - 0.22	-	30	2 – 50
	Waste incineration plant - CHP	5800 - 7425	172 - 258	0.14 - 0.16	0.64 - 0.66	30	2 – 50
Geothermal Eletricity	Geothermal power plant	2575 - 6750	113 - 185	0.11 - 0.14	-	30	5 – 50
Hydro large-scale	Large-scale unit	850 - 3650	35	-	-	50	250
	Medium-scale unit	1125 - 4875	35	-	-	50	75
	Small-scale unit	1450 - 5750	35	-	-	50	20
	Upgrading	800 - 3600	35	-	-	50	-
Hydro small-scale	Large-scale unit	975 - 1600	40	-	-	50	9.5
	Medium-scale unit	1275 - 5025	40	-	-	50	2
	Small-scale unit	1550 - 6050	40	-	-	50	0.25
	Upgrading	900 - 3700	40	-	-	50	-
Photovoltaics	PV plant	2950 - 4750	30 - 42	-	-	25	0.005 - 0.05
Solar thermal electricity	Concentrating solar power plant	3600 - 5025	150 - 200	0.33 - 0.38	-	30	2 – 50
Tidal stream energy	Tidal (stream) power plant – shoreline	5650	145	-	-	25	0.5
	Tidal (stream) power plant - nearshore	6825	150	-	-	25	1
	Tidal (stream) power plant - offshore	8000	160	-	-	25	2
Wave energy	Wave power plant - shoreline	4750	140	-	-	25	0.5
	Wave power plant - nearshore	6125	145	-	-	25	1
	Wave power plant - offshore	7500	155	-	-	25	2
Wind onshore	Wind power plant	1125 - 1525	35 - 45	-	-	25	2
Wind offshore	Wind power plant - nearshore	2450 - 2850	90	-	-	25	5
	Wind power plant - offshore: 5…30km	2750 - 3150	100	-	-	25	5
	Wind power plant - offshore: 30…50km	3100 - 3350	110	-	-	25	5
	Wind power plant - offshore: 50km…	3350 - 3500	120	-	-	25	5

Source: Green-X database, 2011

In 2009 typical PV system costs were in the range of 2,950 €/kW to 4,750 €/kW. These cost levels were reached after strong cost declines in the years 2008 and 2009. This reduction in investment costs marks an important departure from the trend of the years 2005 to 2007, during which costs remained constant, as rapidly expanding global PV markets and a shortage of silicon feedstock put upward pressure on both, module prices and non-module costs (see e.g. Wiser et al 2009). Before this period of stagnation, PV systems had experienced a continuous decline in costs since the start of commercial manufacture in the mid 1970's following a typical learning curve. The new dynamic began in 2008, as expansions on the supply-side coupled with the financial crisis led to softness within the PV market. Consequently, actual cost developments are again in line with (previous) learning expectations. Furthermore, the cost decrease has been stimulated by the increasing globalization of the PV market, especially the stronger market appearance of Asian manufacturers.

The investment costs of wind onshore power plants are currently in the range of 1,125 €/kW and 1,525 €/kW and thereby slightly higher than in the last year. Two major trends have been characteristic for the wind turbine development for a long time: while the rated capacity of new machines has increased steadily, the corresponding investment costs per kW dropped. Increases of capacity were mainly achieved by up-scaling both, tower height and rotor size. The largest wind turbines currently available have a capacity of 5 to 6 MW and a rotor diameter of up to 126 meters. The impact of economies of scale associated with the turbine up-scaling on turbine costs is evident: the power delivered is proportional to the diameter squared, but the costs of labour and material for building a larger turbine are constant or even fall with increasing turbine size, so that turbine capacity increases disproportionally faster than costs increase. From around 2005 on the investment costs have started to increase again. This increase of investment cost was largely driven by the tremendous rise of energy and raw material prices as observed in recent years, but by manufacturers that improving their profitability, by shortages in certain turbine components and by improved turbine design.

Generation costs for RE technologies

While the investments costs for RE technologies as described above are suitable for an analysis at technology level, for the comparison of technologies the generation costs appear more important. Consequently, the broad range of generation costs for several RE technologies is discussed below. Impacts as variations in resource- (e.g. for photovoltaics or wind energy) or demand-specific conditions (e.g. full load hours in case of heating systems) within and between countries as well as variations in technological options such as plant sizes and/or conversion technologies were taken into account. Figure 52 shows the typical current bandwidth of long-run marginal generation costs92 per RE technology for the electricity sector in Europe. In this context, for the calculation of the capital recovery factor a default setting is applied with a payback time of 15 years and weighted average cost of capital of 6.5%. This approach represents an investor's view rather than considering the full levelized costs over the lifetime of an installation.

[92] Long-run marginal costs are relevant for the economic decision whether to build a new plant or not.

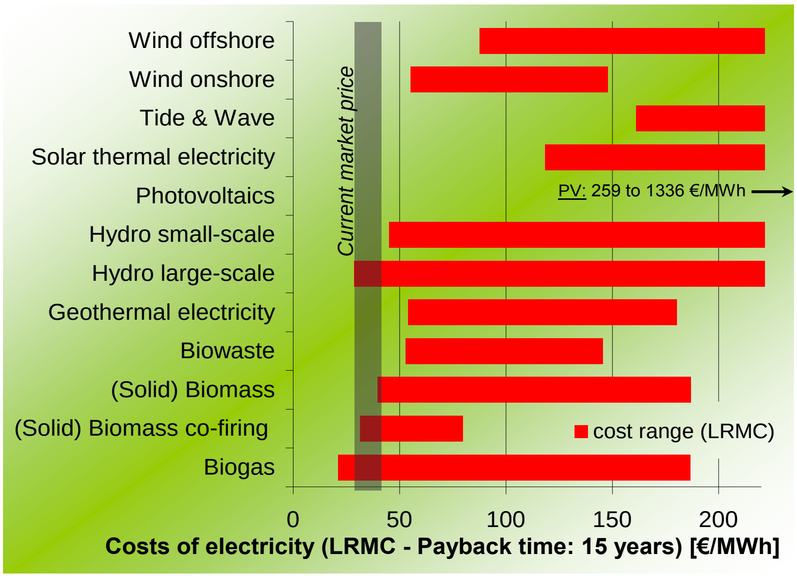

Figure 52: Bandwidth of long-run marginal generation costs (for the year 2009) for various RES-E options at EU level (

Source: Green-X database

As shown in Figure 52 cost levels as well as the costs ranges vary strongly between the different technologies. The most cost efficient options like large hydropower or selected biogas options (i.e. landfill gas, sewage gas) can generate electricity below market prices. It is also noticeable that wind power (onshore) cannot deliver electricity at market prices even at the best sites. Of course, this proposition holds only for current market prices, which have decreased substantially in the wholesale market in the near past. As for most RES-Electricity (RES-E) technologies the cost range at the EU level appears comparatively broad, a more detailed illustration of electricity generation costs for selected RES-E technologies is given in Figure 52 where the bandwidth of generation costs is illustrated by country. More precisely, these graphs show the minimum, maximum and average electricity generation costs for wind onshore and photovoltaics. It can be observed that to some extent both, the average weighted generation costs and the ranges differ considerably. To a lesser extent this can be ascribed to (small) differences in investment costs between the Member States, but more important in this respect are the differences in resource conditions (i.e. the site-specific wind conditions in terms of wind speeds and roughness classes or solar irradiation and their formal interpretation as feasible full load hours) between the Member States. In the case of photovoltaics the broad cost range results also from different types of photovoltaic applications whereby the upper boundary refers to facade-integrated PV systems.

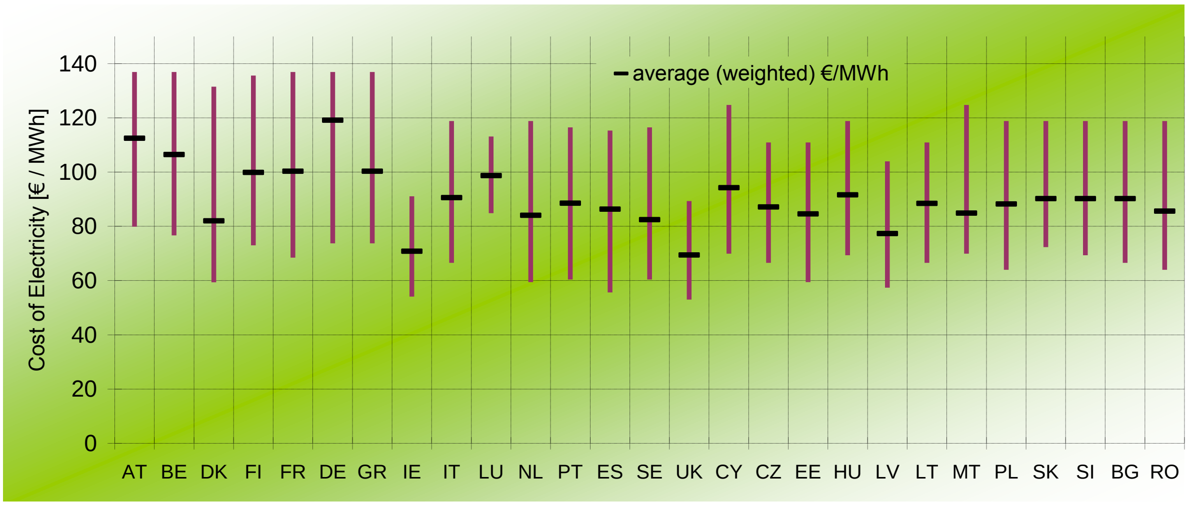

Figure 53: **Bandwidth of long-run marginal generation costs (for the year 2009) for wind onshore by EU country**

Source: Green-X database

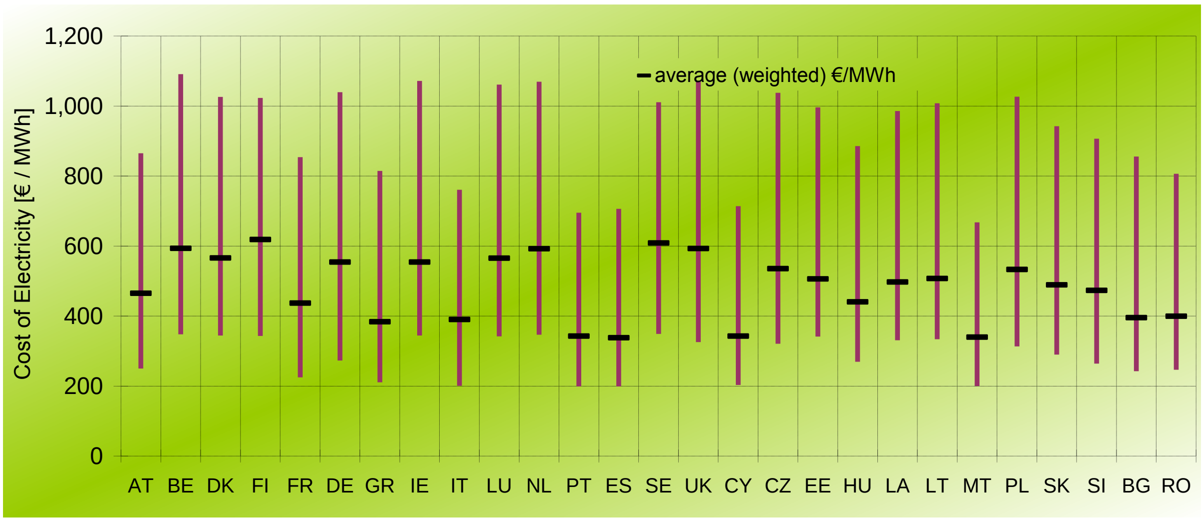

Figure 54: **Bandwidth of long-run marginal generation costs (for the year 2009) for photovoltaics by EU country**

Source: Green-X database

Rendering the cost curves dynamic

Aim of this chapter is to analyse the impact of dynamic aspects on the costs and potentials for RES assessed above. Dynamic factors discussed in this chapter represent important input parameter to the model based scenario assessment of chapter 5. The impact of energy policies (which obviously may also change over time) however is neglected here as this is subject of the scenario assessment of chapter 5. The illustration of these impacts can be done only in a schematic way, by showing resulting static (i.e. neglecting such impacts) and dynamic (i.e. incorporating dynamic aspects) cost-resource curves for the realisable RES potentials in Austria up to 2020. "Schematic" means that for each RES category only average (generation) costs are taken into consideration as derived from an illustrative modelling exercise.

Dynamic parameter influencing the economics of RES

Reference energy and carbon prices

National reference energy prices used in this analysis are based on the primary energy price assumptions as used in the draft PRIMES baseline case (as of December 2009). The assumptions applied are illustrated in Table 23. Compared to energy prices as observed in 2007 and the first three quarters of 2008 the price assumptions appear comparatively low for the later years up to 2020.

The CO_2-price in the scenarios presented in this report is also based on recent PRIMES modelling, see Table 24. Actual market prices (for 2006 EU Allowances) have fluctuated between 7 and 30 €/t, with averages fluctuating roughly between 15 and 20 €/t. In the model, it is assumed that CO_2-prices are directly passed through to electricity prices. This is done fuel-specific based on the PRIMES CO_2-emission factors.

Increased RES-deployment can have a CO_2-price reducing effect as it reduces the demand for CO_2-reductions. As RES-deployment should be anticipated in the EU Emission Trading System and the CO_2-price in the Green-X scenarios is exogenously set, this effect is not included, which represents a rather conservative approach.

Table 23: Primary energy price assumptions

International (fossil) reference energy prices					
(low reference price development for imports to the EU - based on PRIMES low (default) energy prices)					
	[Unit]	2005	2010	2015	2020
Oil	[US$2008/boe]	59.4	71.9	72.6	88.4
	[€ 2006 /MWh]	*27.3*	*29.7*	*32.5*	*43.1*
Gas	[US$2008/boe]	39.7	44.2	49.5	62.1
	[€ 2006 /MWh]	*18.2*	*18.2*	*22.1*	*30.3*
Coal	[US$2008/boe]	14.0	17.2	21.7	25.8
	[€ 2006 /MWh]	*6.5*	*7.1*	*9.7*	*12.6*

Source: PRIMES baseline (2009) and reference case (2010)

Table 24: CO_2 price assumptions

CO_2 price assumptions for the European ETS	[Unit]	2005	2010	2015	2020
PRIMES reference case 2010 (moderate energy prices & demand)	[$€_{2006}$/t CO_2]	0.0	10.5	12.8	15.5
PRIMES baseline case 2009 (moderate energy prices & high energy demand)	[$€_{2006}$/t CO_2]	0.0	13.7	18.8	23.6

Source: PRIMES baseline (2009) and reference case (2010)

Reference prices for the electricity sector are taken from the Green-X model. Based on the primary energy prices, the CO_2-price and the country-specific power sector, the Green-X model determines country-specific reference electricity prices for each year in the period 2006 to 2020. Reference prices for the heat and transport sector are based on primary energy prices and the typical country-specific conventional conversion portfolio. Default sector reference energy prices for the ambitious policy pathway are illustrated in Table 25. More precisely, these prices represent the average at European level (EU-27) and refer to an energy demand development according to the PRIMES reference case as of 2010 and corresponding energy price assumptions. Note that heat prices in case of grid-connected heat supply from district heating and CHP-plants do not include the cost of distribution. A graphical illustration of the EU average of all reference electricity prices used in this analysis is given in Figure 55.

Table 25: Sectoral energy prices

Sectoral reference energy prices - on average at EU-27 level (default reference price development - based on PRIMES reference case) (expressed per MWh output)	[Unit]	2006	2010	2015	2020	average (11-20)
Electricity price (wholesale)	[€/MWh electricity]	59.9	41.4	48.7	47.9	47.3
Heat price (grid-connected)	[€/MWh heat, grid]	29.3	29.3	34.2	43.5	35.2
Heat price (decentral)	[€/MWh heat, decentral]	55.1	56.5	62.3	76.2	65.2
Transport fuel price	[€/MWh transport fuel]	34.8	37.1	40.6	53.9	43.7

Source: based on PRIMES baseline (2009) and reference case (2010) as well as Green-X

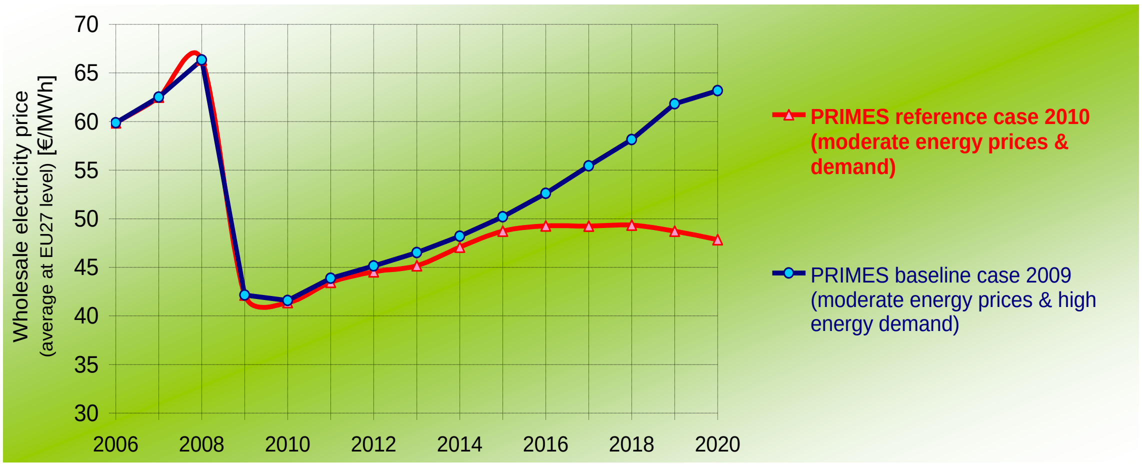

Figure 55: **Assumed development of the wholesale electricity prices on average at EU-27 level (based on Green-X)**

Prices for biomass feedstock

There are high expectations regarding the future potential of biomass. An illustration of a possible future development up to 2020 of biomass feedstock prices (on average at EU-27 level) is exemplarily given in Figure 56 for the default case of low to moderate energy prices sketched above. In this context, their future development is internalized in the overall model – linked to fossil fuel prices[93] as well as the available additional potentials.

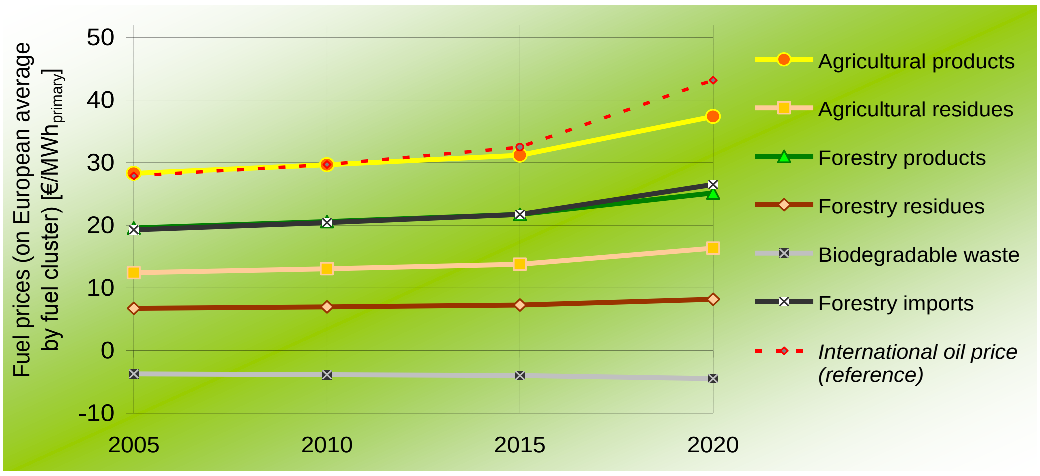

Figure 56: **Future development of biomass fuel prices (on average at EU-27 level) in case of default energy price assumptions (low to moderate energy prices)**

[93] The linkage and correlation of fossil and bioenergy prices and in particular their price volatility has been comprehensively assessed recently in Kranzl et al. (2009). Thereby, the following reasons have been identified for the empirically observable and partly high correlation of various biomass commodities to the historic oil price development: On the one hand, volatile fossil energy prices are indeed a cost factor for the production of biomass, specifically for biomass stemming from the agricultural sector. On the other hand, the coupling of bioenergy to energy markets is increasing (i.e. bioenergy is used as substitute of fossil energy). Thus, price volatility on one market (e.g. oil) impacts the price stability on the other market (e.g. vegetable oil).

Technological change - future cost and performance expectations

A brief overview of costs is given in this section taking into account technological learning. For most RES-E technologies the future development of investment costs is based on technological learning. As learning is taking place on the international level the deployment of a technology on the global market must be considered. For the model-based scenario assessment global deployment consists of the following components:

- Deployment within the EU 27 Member States that is endogenously determined, i.e. is derived within the model;
- Expected developments in the "rest of the world" that are based on forecasts as presented in the IEA World Energy Outlook (IEA, 2009).

Table 26: Assumed learning rates in case of moderate (default) and pessimistic learning expectations – exemplarily depicted for selected RES-E technologies

Assumed learning rates for selected RES-E technologies	Geographical scope	Moderate learning (default)		
		2006 - 2010	2011 - 2020	2021 - 2030
Solid biomass - small-scale CHP	global learning system	cost increase*	10.0%	10.0%
Photovoltaic	global learning system	20.0%	17.5%	15.0%
Wind energy	global learning system	cost increase*	9.0%	6.0%

Note: *A cost increase (compared to 2006 levels) up to 2008 is assumed for solid biomass and wind energy (as well as for almost all other energy technologies) in line with past observations. This increase is mainly caused by rising energy and raw material prices and in line with the assumptions on the development of energy prices (where high energy prices serve as default reference).

For the subsequent scenario assessment we apply a moderate scenario with respect to underlying assumptions on future technological progress, with moderate expectations on future cost reductions being driven by moderate learning rates. Assumed learning rates are shown for both cases in Table 26 and Figure 57. The consequences of the assumed technology learning rates and efficiency improvements regarding the cost reduction of RES are shown in Figure 57 exemplarily for the electricity sector and the Green-X scenario of "strengthened national RES support". The increase of investment costs of wind energy over the last years was largely driven by the tremendous rise of energy and raw material prices as observed in recent years and expected to prolong in the near to mid future.94 However, still substantial cost reductions are observable and expected for novel technology options such as photovoltaics or solar thermal electricity.

[94] For wind energy also an overheating of the global market was observable throughout that period, where supply could not meet demand. This leads to a higher cost increase compared to other energy technologies.

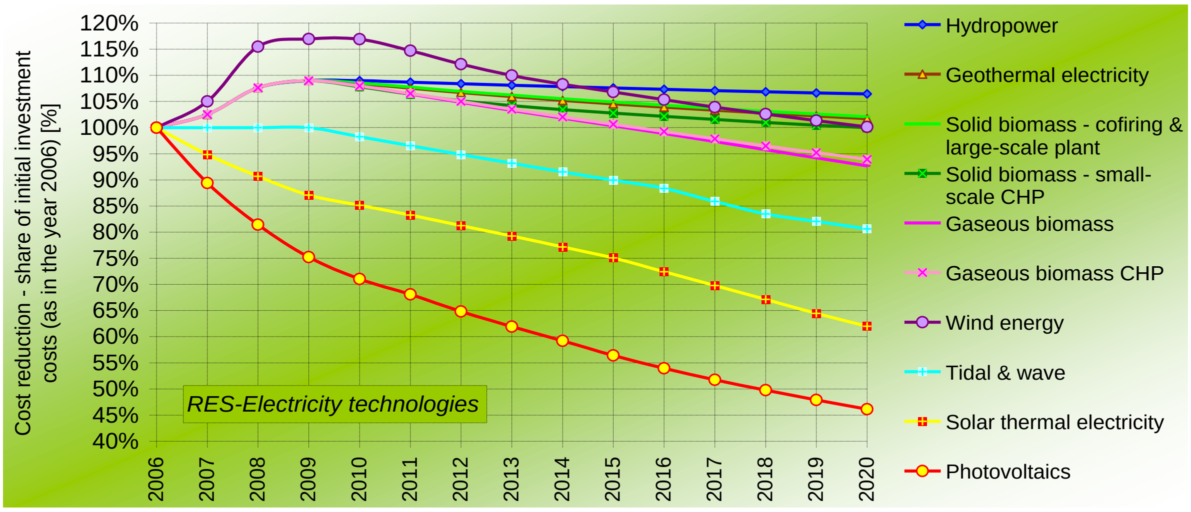

Figure 57: Cost reductions of RES-E investment costs as share of initial investment costs (2006) based on moderate technological learning expectations (default) according to the scenario "strengthened national support" (in line with 20% RE by 2020)

Static and dynamic cost-resource curves for RES in Austria

Finally, we illustrate the impact of key dynamic input parameters on the economic performance of RES in future years. In line with the overall focus of this study we focus on the 2020 timeframe. Both, Figure 58 and Figure 59 provide a schematic[95] depiction of the future potential and corresponding costs for RES in Austria up to 2020 by means of cost-resource curves. While the first figure ignores the impact of dynamic aspects discussed in the previous chapter (static cost-resource curve), the latter incorporates their impacts (dynamic cost-resource curve). In order to illustrate the impact on the economic performance of RES arising from the reference price for conventional energy supply, the concepts of additional generation costs is used for this illustration. Additional generation costs are "the levellised cost of renewable energy minus the reference price for conventional energy supply whereby the levellising is done over the lifetime" (Resch et al., 2009).

[95] "Schematic" means that for each RES category only average (generation) costs are taken into consideration as derived from an illustrative modeling exercise. In contrast to this, the Green-X database and the corresponding model use a detailed level of specifying costs and potentials. The analysis is not based on average costs per technology. For each technology a detailed cost-curve is specified endogenously for each year, based on so-called cost-bands. These cost-bands summarize a range of production sites that can be described by similar cost factors. For each technology like wind onshore or photovoltaics a minimum of 6 to 10 cost bands are specified by country. For biomass due to the broad set of conversion technology options as well as related feedstock categories at least 50 cost bands are specified for each year in each country.

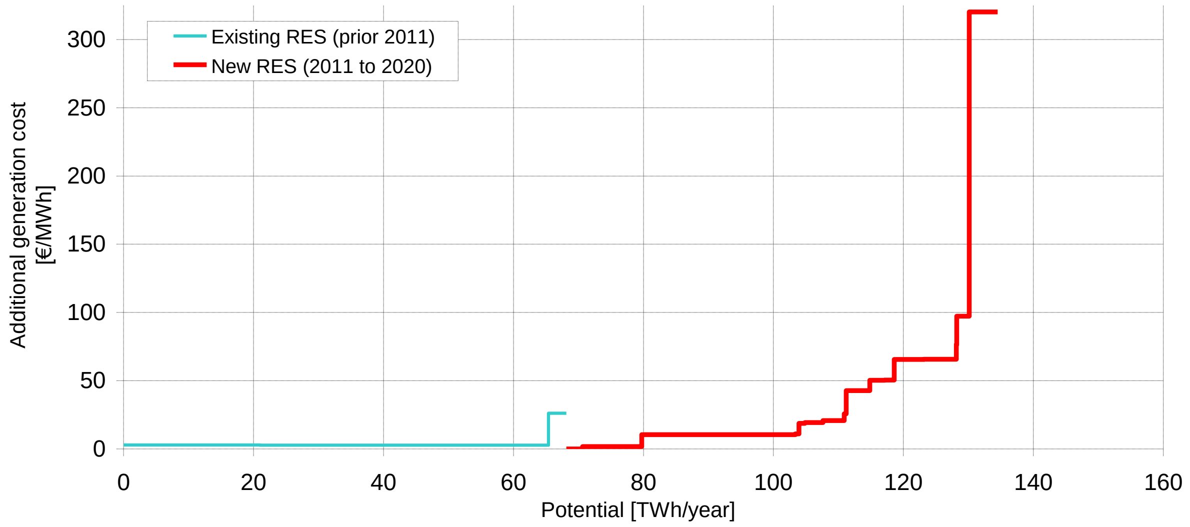

Figure 58: **Schematic static cost-resource curve illustrating the feasible RES deployment up to 2020 ignoring the impact of dynamic aspects**

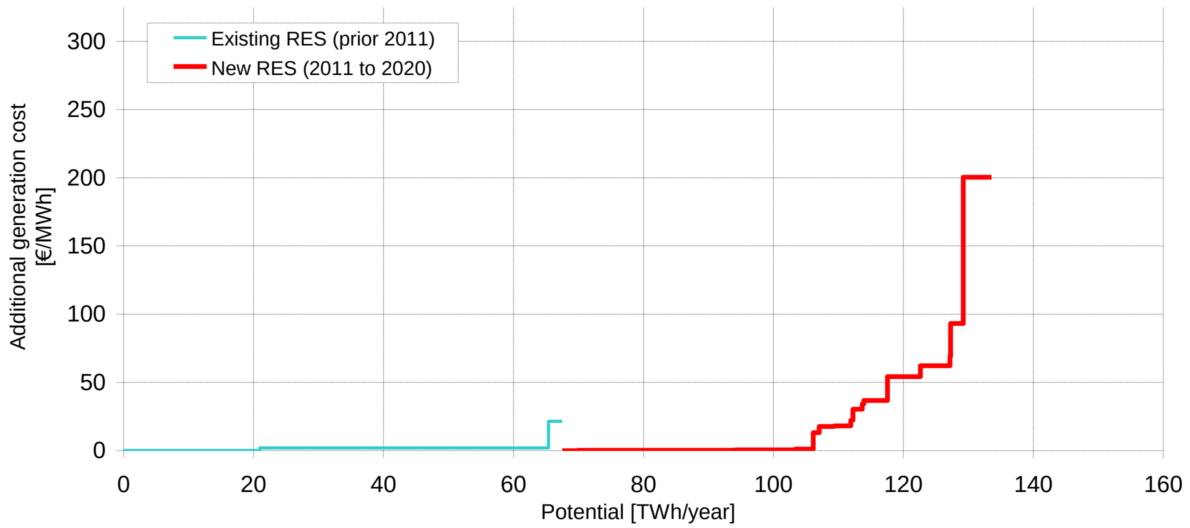

Figure 59: **Schematic dynamic cost-resource curve illustrating the feasible RES deployment up to 2020 considering dynamic aspects**

As can be seen from the comparison of both figures, it is important to consider dynamic effects as they influence the economic performance of RES considerably.